

**Science Teacher Preparation in California:
Standards of Quality and Effectiveness for
Subject Matter Programs**

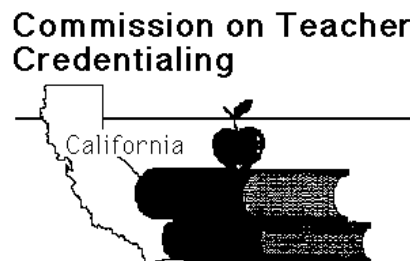
**Handbook for Teacher Educators
and Program Reviewers**

**Commission on Teacher Credentialing
State of California**

1992

Science Teacher Preparation in California: Standards of Quality and Effectiveness for Subject Matter Programs

**Created and Recommended by the
Science Teacher Preparation and
Assessment Advisory Panel
(1989-91)**



**Adopted and Implemented by the
Commission on Teacher Credentialing
State of California
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State of California

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1992

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Standards of Quality and Effectiveness for Science Teacher Preparation in California

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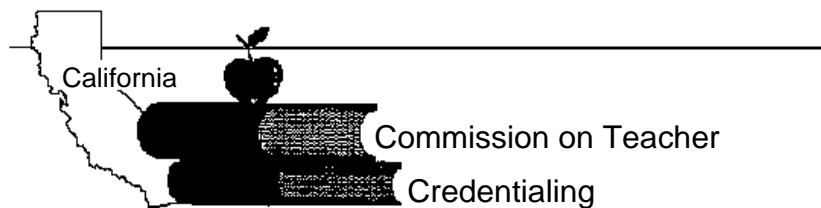
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Part 1

Introduction to Science Standards



Standards and Credentials for Teachers of Science: Foreword by the Commission on Teacher Credentialing

One of the purposes of education is to enable students to learn the important subjects of the school curriculum, one of which is science. Each year in California, more than one million students enroll in science classes with teachers who are certified by the Commission on Teacher Credentialing to teach those classes in public schools. The future well being of California and the nation depends in part on how well these students learn to use science thoughtfully and skillfully. Their ability to do so depends substantially on the quality of teacher preparation in science and science teaching.

The Commission is the agency of California government that certifies the competence of teachers and other professionals who serve in the public schools. As the policy-making body that establishes and maintains standards for the education profession in the State, the Commission is concerned about the quality and effectiveness of the preparation of teachers and other school practitioners. On behalf of the education profession and the general public, the Commission's most important responsibility is to establish and implement strong, effective standards of quality for the preparation and assessment of credential candidates.

In 1988 and 1992 the Legislature and the Governor enacted laws that strengthened the professional character of the Commission, and enhanced its authority to establish rigorous standards for the preparation and assessment of prospective teachers. As a result of these reform laws (Senate Bills 148 and 1422, Bergeson), a majority of the Commission members are professional educators, and the agency is responsible for establishing acceptable levels of quality in teacher preparation and acceptable levels of competence among beginning teachers. To implement the reform statutes, the Commission is developing new standards and other policies collaboratively with representatives of postsecondary institutions and statewide leaders of the education profession.

To ensure that future teachers of science have the finest possible education, the Commission decided to establish two panels of experts to review recent developments in science education, and to recommend new standards for the academic preparation of science teachers in California. The Commission's Executive Director invited colleges, universities, professional organizations, school districts, county offices of education and other state agencies to nominate distinguished professionals to serve on these panels. After receiving nearly 145 nominations, the Director appointed the Life Science Teacher Preparation and Assessment Advisory Panel and the Physical Science Teacher Preparation and Assessment Advisory Panel (see pages ii-iii). These thirty-five professionals were selected for their expertise in science education, their effectiveness as teachers and professors of science, and their leadership in the field of science teaching. To represent the diversity of California educators, the panels included science teachers and curriculum specialists as well as university professors and administrators. The two panels decided to constitute themselves as a single panel in science, and they met together on several occasions during 1989 and 1990 to discuss, draft and develop the standards in this handbook. The Commission is deeply grateful to the panelists for their conscientious work in addressing many complex issues related to excellence in the subject matter preparation of science teachers.

Two Science Teaching Credentials

The Single Subject Teaching Credential in Life Science and the Single Subject Teaching Credential in Physical Science authorize individuals to teach science classes in departmentalized settings. Holders of these credentials may teach at any grade level, but the great majority of science teachers serve in grades seven through twelve. The Life Science Credential authorizes the teaching of life science classes, and the Physical Science Credential authorizes instruction in chemistry, physics, geoscience and physical science. Both credentials authorize the teaching of general science classes.

The Commission asked the Science Teacher Preparation and Assessment Advisory Panels to recommend new policies to ensure that future teachers of science are well prepared in the subjects that are most commonly taught in science classes. In 1988-89, when the Advisory Panels were established, thirty-seven percent (37%) of all science classes in California public schools were *general courses in science* for students in grades seven through twelve. These classes normally included instruction in life science and physical science. Other classes taught by science teachers were more specialized courses in the following subjects.

Biology and Advanced Biology	29% of All Science Classes
Physical Science Courses	13%
Chemistry and Advanced Chemistry	9%
Physics and Advanced Physics	4%
Earth and Environmental Science	4%
All Other Science Subjects	5%

The standards and other requirements in this document are designed to prepare teachers for comprehensive classes in general science as well as the more specialized courses listed above.

Proposal to Streamline the Science Credential Structure

The Commission recently decided to streamline the structure of science teaching credentials by combining the Life Science and Physical Science Credentials into one Teaching Credential in Science. To verify their competence in science, candidates for the combined credential will be required to (1) demonstrate specialized preparation in biological science, or chemistry, or geoscience, or physics, and (2) satisfy a general standard of competence and knowledge across all four areas of science. For the specialized preparation, each future teacher would select a discipline for advanced study. The combined credential would authorize teachers to instruct courses in general science, integrated science, life science, physical science, and their areas of concentration.

The decision to streamline the structure of science teaching credentials was recommended by the Commission's Advisory Panel on Streamlining the Credential System, and was strongly supported by the Life Science and Physical Science Advisory Panel. The decision will require an act of the Legislature; the Commission plans to sponsor enabling legislation in 1993.

The standards in this handbook are the Commission's Standards of Program Quality and Effectiveness for the Single Subject Teaching Credential in Science, with specialized preparation in Biological Science, or Chemistry, or Geoscience, or Physics. The requirements in the handbook are designed to enable prospective teachers to qualify for this combined credential in the future.

Subject Matter Preparation Programs for Prospective Teachers

An applicant for a Single Subject Teaching Credential must demonstrate subject matter competence in one of two ways. The applicant may earn a passing score on a subject matter examination that has been adopted by the Commission. Alternatively, the prospective teacher may complete a subject matter preparation program that has been approved by the Commission (Education Code Sections 44280 and 44310). Regionally accredited colleges and universities that wish to offer subject matter programs for prospective teachers must submit those programs to the Commission for approval.

In California, subject matter preparation programs for prospective teachers are not the same as undergraduate degree programs. Postsecondary institutions govern academic programs that lead to the award of degrees, including baccalaureate degrees in science. The Commission sets standards for academic programs that lead to the issuance of credentials, including the Single Subject Teaching Credential. An applicant for a teaching credential must have earned a Bachelor's degree from an accredited institution, but the degree *may* be in a subject other than the one to appear on the credential. Similarly, degree programs for undergraduate students in science may or may not fulfill the Commission's standards for the subject matter preparation of teachers. Completing a subject matter program that satisfies the standards enables a candidate to qualify for the Single Subject Teaching Credential.

The Commission asked the Science Teacher Preparation and Assessment Advisory Panels to create new standards of program quality and effectiveness that could be used to review and approve subject matter preparation programs. The Commission requested the development of standards that would emphasize the knowledge, skills and perspectives that teachers must have in order to teach science effectively in the public schools.

Standards of Program Quality and Effectiveness

In recent years the Commission has thoroughly redesigned its policies regarding the preparation of education professionals and the review of preparation programs in colleges and universities. In initiating these reforms, the Commission embraced the following principles or premises regarding the governance of educator preparation programs. The Commission asked the Science Teacher Preparation and Assessment Advisory Panels to apply these general principles to the creation of standards for subject matter programs in science.

- (1) *The status of teacher preparation programs in colleges and universities should be determined on the basis of standards that relate to significant aspects of the quality of those programs.* Program quality may depend on the presence or absence of specified features of programs, so some standards require the presence or absence of these features. It is more common, however, for the quality of educational programs to depend on *how well* the program's features have been designed and implemented in practice. For this reason, most of the Commission's program standards define levels of quality in program features.
- (2) *There are many ways in which a teacher preparation program could be excellent.* Different programs are planned and implemented differently, and are acceptable if they are planned and implemented well. The Commission's standards are intended to differentiate between good and poor programs. The standards do not require all programs to be alike, except in their quality, which assumes different forms in different environments.

Foreword by the Commission: Standards for Science Teachers

- (3) *The curriculum of teacher education plays a central role in a program's quality.* The Commission adopts curriculum standards that attend to the most significant aspects of knowledge and competence. The standards do not prescribe particular configurations of courses, or particular ways of organizing content in courses, unless professionals on an advisory panel have determined that such configurations are essential for a good curriculum. Similarly, curriculum standards do not assign unit values to particular domains of study unless there is a professional consensus that it is essential for the Commission's standards to do so. Curriculum standards developed by the Science Advisory Panels are Standards 1-11 below.
- (4) *Teacher education programs should prepare candidates to teach the public school curriculum effectively.* The major themes and emphases of subject matter programs for teachers must be congruent with the major strands and goals of the school curriculum. It is also important for future teachers to be in a position to improve the school curriculum on the basis of new developments in the scholarly disciplines, and in response to changes in student populations and community needs. However, it is indispensable that the Commission's standards give emphasis to the subjects and topics that are most commonly taught in public schools.
- (5) *In California's public schools, the student population is so diverse that the preparation of educators to teach culturally diverse students cannot be the exclusive responsibility of professional preparation programs in schools of education.* This preparation must begin early in the collegiate experience of prospective teachers. The Commission expects subject matter preparation programs to contribute to this preparation, and asked the Science Advisory Panels to recommend appropriate program standards. The panel concurred with this request and developed Standard 11 on page 28.
- (6) *The curriculum of a teacher education program should be based on an explicit statement of purpose and philosophy. An excellent program also includes student services and policies such as advisement services and admission policies.* These components of teacher preparation contribute significantly to its quality; they make the program more than a collection of courses. The Commission asked the Science Advisory Panels to develop standards related to (a) the philosophy and purpose of science teacher preparation and (b) significant, non-curricular components of teacher preparation, to complement the curriculum standards. Again, the panel concurred, and the results are Standards 1 and 12 through 16.
- (7) *The Commission is concerned about the high level of attrition among beginning teachers, and has successfully sponsored legislation to improve the conditions in which new teachers work.* Reality-based career exploration is also needed, to ensure that credential candidates are aware of the challenges of teaching before they invest heavily in professional preparation. The Commission considers subject matter preparation programs to be occasions when students should explore the realities of teaching children and adolescents in schools.
- (8) *The assessment of each student's attainments in a teacher education program is a significant responsibility of the institution that offers the program.* This assessment should go beyond a review of transcripts to verify that acceptable grades have been earned in required and elective courses. The specific form, content and methodology of the assessment should be determined by the institution. In each credential category, the Commission's standards attend to the overall quality of institutional assessment of students in programs. Standard 15 on page 32 is consistent with this policy of the Commission.

Foreword by the Commission: Standards for Science Teachers

- (9) *The Commission's standards of program quality allow quality to assume different forms in different environments.* The Commission did not ask the advisory panels to define all of the acceptable ways in which programs could satisfy a quality standard. The standards should define *how well* programs must be designed and implemented; they must not define specifically and precisely *how* programs should be designed or implemented.
- (10) *The Commission's standards of program quality are roughly equivalent in breadth and importance.* The standards are grouped in categories that are also roughly equivalent in scope. Each standard is accompanied by a rationale that states briefly why the standard is important to the quality of teacher education. The standards are written in clear, plain terms that are widely understood. This Handbook includes only three technical terms, which are defined on page 13.
- (11) *The Commission assists in the interpretation of the standards by identifying the important factors that should be considered when a program's quality is judged.* The Commission's adopted standards of program quality are mandatory; each program must satisfy each standard. Factors to consider are not mandatory in the same sense, however. Instead, these factors suggest the types of questions that program reviewers ask, and the types of evidence they assemble and consider, when they judge whether a standard is met. Factors to consider are not "mini-standards" that programs must "meet." The Commission expects reviewers to weigh the strengths and weaknesses of a program as they determine whether a program meets a standard. The Commission does not expect every program to be excellent in relation to every factor that could be considered.
- (12) *Whether a particular program fulfills the Commission's standards is a judgment that is made by professionals who have been trained in interpreting the standards.* Neither the Commission nor its professional staff make these judgments without relying on experts who are thoroughly trained in program review and evaluation. The review process is designed to ensure that subject matter programs fulfill the Commission's standards initially and over the course of time.

The Commission fulfills one of its responsibilities to the public and the profession by adopting and implementing standards of program quality and effectiveness. While assuring the public that educator preparation is excellent, the Commission respects the considered judgments of educational institutions and professional educators, and holds educators accountable for excellence. The premises and principles outlined above reflect the Commission's approach to fulfilling its responsibilities under the law.

Standards and the Availability of Qualified Science Teachers

In addition to ensuring the qualifications of teachers, the Commission is concerned that there be a sufficient number of teachers. For this reason, the Commission in 1989 gave the advisory panels extensive information about science teacher supply and demand in California. The panel reviewed quantitative data and anecdotal reports about:

- The numbers of new teachers of science employed by California school districts, and fluctuations over time in the demand for science teachers.
- The numbers of teachers receiving science teaching credentials from the Commission, and fluctuations over time in the credentialing of science teachers.

Foreword by the Commission: Standards for Science Teachers

- The numbers of teachers receiving *emergency* credentials to teach science, and fluctuations over time in the demand for these emergency teachers of science.
- The numbers of college and university students preparing to become teachers of science, and fluctuations over time in the potential supply of science teachers.
- The numbers of science teachers who move into California each year after earning degrees and credentials outside of California.

The advisory panels reviewed these data carefully and concluded that the overall supply of science teachers in 1989-90 was sufficient to meet the needs of California school districts. This situation could change, of course, if student enrollments or teacher retirements increase more sharply than expected. For this reason, the Commission will continue to monitor trends in science teacher supply and demand. Moreover, there may not be a sufficient number of science teachers who would accept positions in particular schools or districts, but this is a circumstance over which the Commission will always have little influence. Given the statistical evidence that was available, the Commission asked the advisory panel to concentrate on defining the levels of quality that the Commission should require in subject matter preparation programs for future science teachers.

Analysis and Adoption of the Science Program Standards

The Science Teacher Preparation Advisory Panels drafted the standards in this Handbook over the course of ten months. The standards were reviewed and discussed by the Commission in a public meeting. Then the Commission distributed the draft standards to science educators throughout California, with a request for comments and suggestions. The draft standards were forwarded to:

- Academic administrators of California colleges and universities;
- Chairpersons of science departments in California colleges and universities;
- Deans of Education in California colleges and universities;
- Presidents of professional associations of teachers and science teachers;
- Superintendents of county offices of education in California;
- Superintendents of school districts in California; and
- Science teachers, professors and curriculum specialists who asked for the document.

The Commission asked county and district superintendents to forward the document to science teachers and curriculum specialists for their analysis and comments. The Commission also conducted two regional meetings (one in northern California and one in southern California) to enable science educators to discuss the draft standards with members of the two Science Advisory Panels.

After the period for public comments, the Commission's professional staff collated the responses to each standard, which were reviewed thoroughly by the advisory panels. The panels exercised their discretion in responding to the suggestions, and made several significant changes in the draft standards. On November 7, 1991, the advisory panels presented the completed standards to the Commission, which adopted the policies in this document on November 8, 1991.

New Science Performance Assessments Adopted by the Commission

Since 1970, many applicants have qualified for Single Subject Credentials in Science by passing two standardized tests that were adopted by the Commission: the National Teachers Examination in Biology and General Science; and the National Teachers Examination in Chemistry, Physics and General Science. These prospective teachers of science qualified for credentials without completing approved programs of subject matter study. In 1987 the Commission completed an extensive study of the validity of the NTE Exams. Based on the results of this research, the Commission in 1989 asked the Science Teacher Preparation and Assessment Advisory Panels to develop new specifications for the tests of scientific knowledge, and to develop a new assessment of subject matter competence for prospective teachers of science.

The Commission asked the panels to design subject matter assessments that would be as parallel and equivalent as possible with the subject matter program standards. The advisory panels developed new specifications for a comprehensive test of science, including examinations of breadth and depth. The panels also developed specifications and model questions for new essay examinations that assess the ability to respond knowledgeably and competently to scientific problems. The Commission distributed the panels' proposed specifications to science teachers, professors and curriculum directors throughout California. Following an extensive review of the draft specifications, the panels made several revisions, and the completed specifications were adopted by the Commission.

The Commission awarded a contract to Educational Testing Service to develop new Content Area Performance Assessments in Life Science and Physical Science that would match the advisory panels' specifications. On four occasions these new essay examinations were pilot-tested and field-tested throughout California. Following each test, the panels examined the participants' responses and revised the test questions. The panels also developed detailed criteria for scoring candidates' responses, which were also field-tested in practice. On April 5, 1991, the Commission adopted a plan for implementing the Content Area Performance Assessment in California, and on July 19 the Commission adopted passing standards for the CAPAs in Life Science and Physical Science. After the first administration of the new assessments, the Commission examined the impact of the newly-adopted passing standards on all examinees.

The Commission's new specifications for the assessment of science knowledge and competence were presented to a national test development committee that was appointed by Educational Testing Service. Based on the advice of this committee, ETS developed a battery of multiple-choice tests in science, which are part of the new *Praxis* series of professional examinations for teachers. The new science tests conform to the Commission's specifications and will be administered throughout the nation beginning in 1993-94. *As a result of these initiatives by the Commission, all future candidates for science teaching credentials will qualify by completing subject matter programs that meet standards of program quality and effectiveness, or by passing examinations and performance assessments that are congruent with the program quality standards.*

The Commission's new specifications for the assessment of science knowledge and competence are included in this handbook (pp. 35-47) to serve as a resource for the design and evaluation of subject matter programs for prospective science teachers.

Standards for Professional Teacher Preparation Programs

The effectiveness of the science curriculum in California schools does not depend entirely on the content knowledge of science teachers. Another critical factor is the teachers' ability to *teach* science in classrooms. To address the *pedagogical* knowledge and effectiveness of science teachers, the Commission in 1986 adopted *Standards of Program Quality and Effectiveness for Professional Teacher Preparation Programs*. These thirty-two standards define levels of quality and effectiveness that the Commission expects of teacher education programs that are offered by Schools of Education. The standards originated in the published research literature on teacher education and teacher effectiveness. Approximately 1,500 educators from all levels of public and private education participated in the development of the standards during a two-year process of dialogue and advice. Since 1986 the Commission has updated the 32 standards on two occasions. The revised standards are now the basis for determining the status of *professional preparation programs* for Single Subject Teaching Credentials in California colleges and universities. The standards in this handbook have been designed for subject matter programs, to complement the 32 existing standards for programs of professional preparation.

Subject Matter Standards for Prospective Elementary School Teachers

In the science curriculum, elementary teachers are expected to establish a foundation of knowledge, skills and attitudes that young students need to learn in order to master the more advanced content that science teachers offer in secondary schools. To address the preparation of future classroom teachers in elementary schools, the Commission in 1987 appointed an advisory panel to develop new *Standards of Program Quality for the Subject Matter Preparation of Elementary Teachers*. Following a thorough process of research, development, dialogue and consultation, the Commission in 1988 adopted these standards, which relate to (1) the broad range of subjects (including the sciences) that elementary teachers must learn, and (2) the essential features and qualities of programs offered in liberal arts departments. In 1989 the Commission appointed and trained two professional review teams, which have now examined 73 subject matter programs for prospective elementary teachers, and have recommended 63 of these programs for approval by the Commission. As a result of this reform initiative, approximately twenty thousand prospective elementary school teachers are now engaged in undergraduate programs that meet the Commission's standards of quality for subject matter preparation.

Contributions of the Science Advisory Panel

The Commission on Teacher Credentialing is indebted to the Science Teacher Preparation and Assessment Advisory Panel for the successful creation of *Standards of Program Quality and Effectiveness for the Subject Matter Preparation of Prospective Teachers of Science*. The Commission believes strongly that the standards in this handbook will serve to improve the teaching and learning of science in California's public schools.

Overview of the Science Standards Handbook

Following a statement by the Science Advisory Panel regarding science teaching in California, part 2 of the handbook includes the 16 standards (pp. 13-33) and the panel's Specifications for the Knowledge and Competence of Prospective Teachers of Science (35-47). Part 3 provides information about implementation of the new standards (49-63).

Science Teaching and Teacher Preparation: Introduction by the Science Advisory Panel

The State of California has a responsibility to educate its citizens to be scientifically and technologically literate. Science and technology impact every facet of contemporary life; a good science education empowers students to participate fully in contemporary society. Science is both a body of knowledge and the process of human observation, identification, description, experimental investigation and theoretical explanation of natural phenomena. People practicing science make inferences based on observations, and use existing concepts and theories to build new hypotheses which can be tested, verified, challenged or modified by further experiments. Science has its own character as an intellectual activity; science aims to be testable, objective, and consistent.

A scientifically literate person recognizes this unique character of science and appreciates the contributions of science to society. A technologically literate person recognizes the interrelationships among science, technology and society, and understands the origins, history, and continuing development of our technological society. Effective science teachers are a critical part of an education system that can produce such citizens.

A significant challenge is to develop science programs that prepare students to enter credential programs and teaching careers with excitement about the potential of being an active part of a science education system that serves all the people of the State of California. This section outlines recent trends in the United States and the State of California as background for the directions taken in the Standards of Program Quality and Effectiveness in this document.

National Reports

In *A Nation at Risk: The Imperative for Educational Reform* (1983), the National Commission on Excellence in Education declared that American education had become victim to a "rising tide of mediocrity." Since that report, several hundred national reports have critiqued our society's failure to adequately prepare our citizens with the knowledge and skills they will need for life in our increasingly technological culture. The National Science Board's Commission on Precollege Education in Mathematics, Science and Technology confirmed these failures in *Educating Americans for the 21st Century* (1983). The 1988 National Assessment of Education Progress (NAEP) still reported disappointing science achievement among our nation's students in the *The National Science Report Card* (1989). Recent international comparisons shown in the *Second International Science Study* have placed American students' science knowledge far below countries with comparable standards of living.

Introduction by the Panel: Science Teaching and Teacher Preparation

Summarizing these concerns, Paul DeHart Hurd, Professor Emeritus, Stanford University, in *This Year in School Science* (American Association for the Advancement of Science, 1989) states: "These reports stress that it is time to reformulate the goals of science education to enable individuals to be more adaptable to change . . . we have entered an era of rapid and unpredictable change -- understanding the nature of change, being able to cope with it, and having the ability to adapt successfully to constant change have become educational imperatives. Most of the efforts to improve science education since 1983 have resulted only in intensifying the pattern of conditions that gave rise to the demands for reform. Many of the changes have been reactions to the symptoms rather than reconceptualizations for a new era." The changes attempted include lengthening the school day, increasing course requirements, and increasing student testing, but without reconceptualizing the education goals or changing curriculum and instruction to match those goals. The statistics show that American schools are losing ground in comparison with both our own standards and those of other countries.

The nation's public schools have traditionally provided the means by which our children develop the skills with which to participate in the economic opportunities available in the country. Today our schools are especially hard-pressed to serve the needs of children at risk. Most elementary and secondary schools do an inadequate job of preparing students in science, especially those from underrepresented groups as documented by the NAEP Report (1988) and *Changing America: The New Face of Science and Engineering, Final Report* (Task Force on Women, Minorities and the Handicapped in Science and Technology, 1989). Science teachers must be able to make science learning accessible to *all* students. In its report on *Teachers for the 21st Century* (1986), the Carnegie Forum on Education and Economy recommended that science teachers be empowered to transform traditional school science curricula as a necessary step toward improvement of our educational system.

National Response

These calls for global changes have led to further reports from national organizations that have taken a closer look at the structure and substance of science and mathematics education, and have made specific recommendations for change. Their titles -- *Everybody Counts* from the National Academy of Sciences and Engineering, the *Scope, Sequence, and Coordination Project* of the National Science Teachers' Association, and *Science For All Americans* from the American Association for the Advancement of Science -- provide insights into the concerns of the national professional organizations that have issued them.

The National Science Teachers Association's *Scope, Sequence, and Coordination (SS&C) Project* suggests that every secondary student from grades 7-12 study every science subject (Geosciences, Biology, Chemistry, and Physics) every year, with a gradual progression from descriptive and phenomenological approaches to empirical and semi-quantitative to theoretical and abstract studies. The proposal specifies general goals, but encourages individual school districts to experiment with alternative methods of achieving them. This approach has been endorsed by the Council of Scientific Society Presidents and by resolutions in both the U. S. House of Representatives and the Senate. The National Science Foundation and the U. S. Department of Education have funded projects to begin implementing SS&C, including a major project in California secondary schools to study these and other alternatives to traditional courses and sequences.

Introduction by the Panel: Science Teaching and Teacher Preparation

The American Association for the Advancement of Science's *Project 2061* aims to provide a higher level of scientific literacy to all Americans in the generation that was born in 1985, the first year of the project, and who will live until 2061, the next visit of Halley's Comet. In the first phase of Project 2061, panels of scientists and engineers were asked to delineate the science related knowledge, skills, and attitudes that all citizens should possess. The results were summarized in a central overview document *Science For All Americans*, as well as being published in five separate reports representing different areas of science. The central role of teachers, augmented by a small number of resource persons, is emphasized in the second phase of this project which is developing models of curricula to implement the level and kind of scientific literacy for all students that the first phase envisions. Project 2061 envisions a more thematic, problem-centered and socially relevant approach to the science curriculum than is currently prevalent. San Diego and San Francisco are two of the six school districts in the United States that are serving as Phase II sites.

California Response

These national reports and the thinking they represent have influenced the development of the 1990 *California State Science Framework for California Public Schools, Kindergarten through Grade Twelve*. In addition to a hands-on, mind-on curriculum, the *Framework* calls for:

- attention to the nature of science as a process, a way of obtaining knowledge through inquiry (asking questions, gathering and analyzing data and drawing tentative conclusions) rather than a static body of facts to be memorized; and
- a thematic approach to science teaching that emphasizes the commonalities among the different sciences (life science, geoscience, and physical science) via the recognition of important underlying ideas (e.g., energy, evolution, patterns of change, scale and structure, stability, systems and interactions).

Thus the *California Framework* joins the national reports in calling for a science curriculum that is substantially different from the one we have now. This new curriculum requires adjustments in teacher preparation programs that are currently in place. The Standards of Program Quality in this handbook represent a significant step in the direction of these reforms, recognizing that the existing curriculum will take much time and effort to revise, and that the teachers who complete science teacher preparation programs in 1994 may be in classrooms until 2037. These teachers need to be the leaders in developing and implementing restructured science curricula.

The standards in this handbook are intended to guide the implementation of subject matter preparation programs to prepare new science teachers for the challenges that will confront their careers. Modest steps are taken in the direction of an interdisciplinary, thematic, comprehensive approach to the education of future science teachers. Both the breadth and the depth of students' fundamental science knowledge will have to expand. All science teachers will need to be well versed in the sciences other than their specialty in order to be able to develop curriculum and to convey the comprehensive nature of the scientific enterprise to all students in California. Each discipline must be set in the broader context of science and society, including the ethical concerns that arise from the development and use of technology. Teachers must understand the importance of raising the expectations of all students in science. Many of the diverse cultural groups in California schools are not yet fully represented in science and technology. Teachers need to develop knowledge and skills to inspire and educate students from these underrepresented groups.

Needs of California Elementary and Secondary School Students

As a part of their broad-based education, California students should graduate from high schools with an awareness of the scientific endeavor leading to an understanding of how the natural world functions. Students should understand how science has been translated into the ideas and products they use everyday. They must be able to apply science in their own lives.

In science classes at all grade levels, students should learn in environments that encourage scientific thinking. They should also have practice in developing laboratory and problem-solving skills that are inquiry-based and have real life applications.

Science education should build understanding of the major strands of scientific thought. Students should be encouraged to develop favorable attitudes toward science, to appreciate its coherence, history, logic, and beauty, to enjoy their own practice of its processes, to admire its technological achievements, and to recognize its limitations.

Contributions from diverse cultures to the construction of scientific understanding and to technological development should be recognized by students. Given the increasing role of science in society, all students, regardless of gender or ethnicity, must have equal access to future careers involving science and technology. Science oriented students should have opportunities to further their scientific education with the goal of eventually pursuing careers in pure or applied science, or science education.

As part of becoming scientifically literate, all students should be aware that science and its applications are human enterprises that have strengths and limitations, and they should appreciate that there are benefits and burdens inherent in the use of technology. Moreover, students must be aware of the ethical issues in science and technology, and must understand concepts of science sufficiently to be able to make informed decisions as members of society.

Characteristics of Future Science Teachers in California

For the state to educate its students to become scientifically and technologically literate citizens, California's science teachers must possess many complex skills that will enable them to communicate and demonstrate concepts, principles, processes, attitudes and applications of science and technology equally well to students of both sexes and of diverse ethnic and cultural backgrounds.

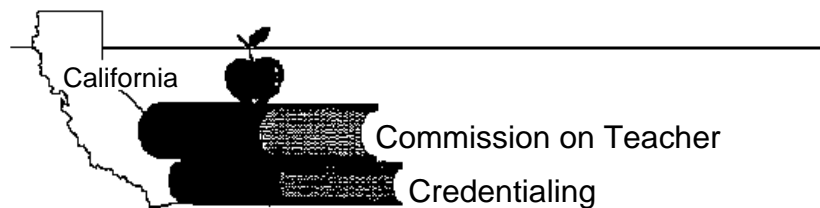
To reflect the cooperative nature of progress in science, and to understand the common bases of the science fields, future teachers must be broadly prepared in all major disciplines of science. Furthermore, to be well-prepared to teach their future students how science operates in detail, participants in subject matter preparation programs must study at least one science discipline in considerable depth.

Science teachers should also be creative, innovative, flexible, and enthusiastic about their own appreciation of science. They need to be knowledgeable about laboratory and field practices, safety concerns, and the history and philosophy of science. Science teachers should be informed about the applications of science, and about careers based on science.

Science teachers in California face an exciting challenge. State agencies, universities and colleges should establish excellent preparation programs and, in collaboration with school districts, provide ongoing support to teachers. Efforts to raise student expectations and performance in science must be a collaboration between practicing teachers and those who prepare new ones.

Part 2

Standards of Program Quality and Effectiveness in Science



Definitions of Key Terms

Standard

A "standard" is a statement of program quality that must be fulfilled for initial or continued approval of a subject matter program by the Commission. In each standard, the Commission has described an acceptable level of quality in a significant aspect of science teacher preparation. The Commission determines whether a program satisfies a standard on the basis of an intensive review of all available information related to the standard by a review panel whose members (1) have expertise in science teacher preparation, (2) have been trained in the consistent application of the standards, and (3) submit a recommendation to the Commission regarding program approval.

The Commission's adopted Standards of Program Quality and Effectiveness for Subject Matter Programs in Science begin on page 15. The Commission's authority to establish and implement the standards derives from Section 44259 (b) (5) of the Education Code.

Factors to Consider

"Factors to consider" guide program review panels in judging the quality of a program in relation to a standard. Within the scope of a standard, each factor defines a dimension along which programs vary in quality. The factors identify the dimensions of program quality that the Commission considers to be important. To enable a program review panel to understand a program fully, a college or university may identify additional quality factors, and may show how the program fulfills these added indicators of quality. In determining whether a program fulfills a given standard, the Commission expects the review panel to consider all of the related quality factors in conjunction with each other. In considering the several quality factors for a standard, excellence on one factor compensates for less attention to another indicator by the institution. For subject matter programs in science, the adopted factors to consider begin on page 15.

Precondition

A "precondition" is a requirement for initial and continued program approval that is based on California state laws or administrative regulations. Unlike standards, preconditions specify requirements for program compliance, not program quality. The Commission determines whether a program complies with the adopted preconditions on the basis of a program document provided by the college or university. In the program review sequence, a program that meets all preconditions is eligible for a more intensive review to determine if the program's quality satisfies the Commission's standards. Preconditions for the approval of subject matter programs in science are on page 14 of this handbook. The program review sequence is described on pages 53-62.

Science Terms

"Life Science" is the study of living organisms and includes biology, anatomy and physiology. Health Science is specifically excluded. "Geoscience" is the study of geology, meteorology and oceanography, and includes astronomy/cosmology. Geography is specifically excluded. "Physical Science" is the study of the physical universe and includes chemistry, physics and the geosciences.

Preconditions for the Approval of Subject Matter Programs in Science

The following Preconditions must be met for the Approval of Subject Matter Programs in Science. The Commission's statutory authority to establish and enforce the preconditions is based on Sections 44310 through 44312 of the California Education Code.

- (1) Each program of subject matter preparation for the Single Subject Teaching Credential in Science shall consist of at least 45 semester units or 68 quarter units of coursework in science and closely related subjects. Each program shall include breadth courses and one or more concentrations as specified in Preconditions 2 and 3.
- (2) Breadth courses shall address Standard 5 by developing foundations in biological sciences, chemistry, geosciences and physics; and shall comprise at least 24 semester units or 36 quarter units.

In addition to describing how a program meets each standard of program quality in this handbook, the program document by an institution shall include a listing and catalog description of all breadth courses that address Standard 5. Institutions shall have flexibility to define the breadth component of a program as (a) a core of required coursework that fulfills Standard 5, or (b) elective coursework that is structured to ensure that each student's studies fulfill Standard 5. Institutions may also determine whether the breadth curriculum consists of (a) distinct courses in biological sciences, chemistry, geosciences and physics, or (b) courses that offer integrated coverage of these subjects.

- (3) Each program shall include at least one of the concentrations under Standard 6, to provide depth of study in an area selected by each student. In each concentration, the depth courses shall comprise at least 18 semester units or 27 quarter units.

A program document shall include a listing and catalog description of all courses that constitute each concentration. Institutions shall have flexibility to define each concentration as (a) a core of specifically required coursework that fulfills Standard 6A or 6B or 6C or 6D, or (b) elective coursework that is structured to ensure that each student's studies fulfill Standard 6A or 6B or 6C or 6D.

Coursework offered by any appropriate department(s) of a regionally accredited institution may satisfy the preconditions and standards in this handbook.

Standards of Program Quality and Effectiveness

Category I: Curriculum and Content of the Program

Standard 1: Program Philosophy and Purpose

Each subject matter preparation program in science is based on an explicit statement of program philosophy that expresses its purpose, design and desired outcomes, and defines the institution's concept of a well-prepared teacher of science. The program and its philosophy are appropriate for preparing students to teach the sciences in California schools.

Rationale for Standard 1

To ensure that a subject matter program is appropriate for future teachers, it should have an explicit statement of philosophy which expresses the institution's concept of a well-prepared teacher of the sciences. This statement provides direction for program design and it assists the faculty in identifying program needs and emphases, developing course sequences and conducting program reviews. The philosophy statement also informs students of the basis for program design, and communicates the institution's aims to school districts, prospective faculty members and the public. Given the multiple purposes of a program philosophy statement, the responsiveness of this statement to the contemporary conditions of California schools is a critical aspect of its quality.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which:

- The program philosophy, design and desired outcomes are collectively developed by participating faculty, reflect an awareness of recent research and thinking in the disciplines of science, and are consistent with each other.
- The program philosophy is consistent with the major themes and emphases of the California State Curriculum Framework, other state curriculum documents, and nationally adopted guidelines for teaching the sciences.
- The statement of program philosophy shows a clear awareness of the preparation that students need in order to teach science effectively among diverse students in California schools.
- Expected program outcomes for students are defined clearly so student assessments and program reviews can be aligned appropriately with program goals.
- The institution periodically reviews and reconsiders the program philosophy, design and intended outcomes in light of ongoing research and thinking in the disciplines, nationally accepted standards and recommendations, and the changing needs of public schools in California.
- The program has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 2

Science Philosophy and Focus

The program is based on a concept of a well educated person; focuses on significant ideas, structures and values within the sciences; and examines the ethical, moral, social, cultural and practical implications of significant ideas in science. Well qualified science students are encouraged to become science teachers in elementary and secondary schools.

Rationale for Standard 2

A program that is based explicitly on a vision of a well-educated person is most likely to be effective in achieving that vision. The knowledge that is most worth learning consists of the ideas, structures, and values that are most significant in the disciplines. By giving emphasis to the ethical, moral, social, cultural and practical implications of ideas in science, programs become vital and interesting to today's students, and contribute to their general education. Science instruction in elementary and secondary schools can be improved when well qualified students pursue teaching careers.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which:

- The institution articulates and the program represents a philosophical vision of the kind of education in the sciences that each student is expected to experience.
- Coursework in the program reflects and emphasizes the basic concepts, intellectual foundations, and key elements of the science disciplines.
- Throughout the program, students encounter and learn to recognize the values and attitudes that characterize the disciplines being studied. Examples of such values and attitudes include respect for evidence, openness to alternatives, tolerance for divergence, and recognition of the intrinsic importance of knowledge.
- Throughout the program, students study and address ethical, moral, social, cultural and practical issues related to the sciences and the implications of these issues for society as a whole.
- The science faculty supports and respects the teaching profession and promotes teaching as a worthwhile career option for well qualified science students.
- The program has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 3

General Academic Quality

The program is academically rigorous and intellectually stimulating. Students are encouraged to develop a broad intellectual background and are required to demonstrate effective communication skills, especially regarding science concepts and methods.

Rationale for Standard 3

The program should be designed carefully to develop well educated individuals who have an in-depth knowledge and understanding of science, and who strive for academic excellence. The program should provide opportunities for students to experience a wide variety of intellectual challenges, including opportunities to practice analyzing complex situations, to make informed decisions, and to participate in scientific problem solving. For prospective teachers of science, it is particularly important that the program develop highly effective written and oral communication skills, especially concerning concepts and methodologies of science.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which the program:

- Requires students to complete coursework that is broad and challenging.
- Requires sufficient practice in written and oral communication skills that students gain high levels of proficiency in those skills.
- Promotes the use of quantitative reasoning.
- Regularly requires students to experience the nature of scientific investigation.
- Encourages students to analyze complex situations, make informed decisions, and participate in scientific problem solving.
- Allows students to gain experience in critical analysis by engaging in such activities as reviewing scientific writings and lectures, and studying the history of scientific thought in the context of political and social development.
- Provides opportunities for students to observe and practice the use of appropriate conceptual and physical models.
- Provides students with experience in constructing and reformulating conceptual models of the natural world which require correcting prior conceptions.
- Has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 4

Integrated Study of Science

The program reflects science as an integrated entity and emphasizes interrelationships among the disciplines of science. Concepts that occur in all science disciplines are examined, and variations in the structures, content and methods of inquiry in the disciplines are studied.

Rationale for Standard 4

Examination of phenomena from the perspectives of different science disciplines leads to a more accurate and complete understanding of the natural world. The ideas that define the scientific endeavor are larger than the facts or concepts that belong to any single field of science. It is therefore essential that the program view science as an integrated entity, emphasize relationships among the sciences, include interdisciplinary studies in science, and examine similarities and differences among the disciplines.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which:

- Basic concepts and principles which underlie all of science are taught throughout the program.
- The program encourages the examination of phenomena from the perspectives of different science disciplines.
- In each student's area of concentration (see Standard 6), the program encourages the development of insights into major themes and a broad view of conceptual interrelationships.
- Instructors in the various disciplines of science are encouraged to meet regularly to exchange ideas and perspectives.
- The program encourages the development of courses that cut across traditional departmental divisions and integrate science as a whole.
- The program incorporates an understanding of the importance and interrelationship of the history and the philosophy of science.
- The program has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 5: Breadth of Study in Science

The overall program in the sciences is organized to assure that students meeting the requirements of the program acquire sufficient general understanding in science so that, as future teachers, they will have the necessary background to impart a high quality general scientific literacy to their students. General studies provide familiarity with the nature of science and major ideas common to all the natural sciences, including: matter and energy, mechanisms and processes of evolution, scientific models and systems, and their interactions. The program provides a foundation for students to engage in further studies of any natural science. General studies in the program familiarize all students with important societal and environmental concerns and the application of scientific principles to everyday phenomena.

Rationale for Standard 5

An effective science teacher needs to be broadly educated in science in order to teach a coordinated science curriculum that emphasizes the major themes and concepts of the biological sciences, chemistry, geosciences, and physics, as reflected in the *Science Framework for California Public Schools, Kindergarten through Grade Twelve*.

Factors to Consider

*When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which **breadth studies** in the program:*

- Encompass the general science specifications for subject matter knowledge and competence on pages 36 through 40, including the following general areas of study:
 - molecular, cellular and organismic biology, the mechanisms by which living systems have evolved, and their interactions as individuals and as populations within ecosystems;
 - the fundamental principles governing the structure of matter and its chemical reactions and interactions;
 - the history and fundamental structure of the universe and the solar system, with emphasis on the planet earth, including its oceans and atmosphere; and
 - the basic principles governing the relationships, interactions and transformations between matter and various forms of energy such as those involved in mechanical, thermal, optical, electrical and magnetic phenomena.
- Encourage students to apply scientific knowledge to everyday experiences and uses of technology.
- Enable students to conceptualize a view of the scientific enterprise as a human endeavor with moral and ethical consequences for society.
- Encourage students to appreciate connections and commonalities among the traditional disciplines of the natural sciences.
- Engage students in decision making, methods of inquiry, and collaborative and cooperative learning groups.
- Exhibit other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 6: Depth of Study in a Concentration Area

Each candidate for the **Single Subject Credential in Science** must complete a subject matter program that includes Concentration 6A, 6B, 6C or 6D.

Concentration 6A: Depth of Study in Biological Sciences

The Concentration in Biological Sciences includes studies of biology substantially beyond those required for general science literacy in Standard 5. The depth and breadth of study in Concentration 6A should be that normally associated with a major in the biological sciences, and should provide conceptual foundations distributed across the discipline. Integral to the concentration are conceptual foundations that include molecular and cellular biology, functional biology of organisms (plants, animals and microbes), ecology, and concepts of evolution, including evolutionary mechanisms and patterns. Concentration 6A includes in-depth study and field/laboratory experiences in biology, achievement of an appropriate level of understanding in mathematics, use of methods employed by scientists in the generation of scientific knowledge, and application of biological sciences to societal issues including ethical and moral considerations.

Rationale for Concentration 6A

Holders of the Science Credential with a Concentration in Biological Sciences will be required to teach a wide variety of courses in their teaching assignments. A thorough coverage of the subject is essential to address the major themes and concepts of the *Science Framework for California Public Schools, Kindergarten through Grade Twelve*. Breadth and depth of understanding of the biological sciences is necessary for teaching advanced and specialized courses, planning curriculum, selecting appropriate educational materials, providing an effective educational program, and serving as a member of an interdisciplinary team of science teachers. Study and application of appropriate mathematics will enable students to solve scientific problems quantitatively.

Factors to Consider

*When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which **depth studies** in Concentration 6A:*

- Encompass the biological science specifications for subject matter knowledge and competence on pages 41 through 43.
- Foster each student's use of computers in classroom applications, and encourage students to apply scientific knowledge to everyday experiences and uses of technology.
- Include demonstration of mathematical skills needed to complete studies that are required by advanced courses in the biological sciences.
- Engage students in decision-making, scientific methods of inquiry, and collaborative and cooperative learning groups.
- Encourage students to apply value-analysis skills and to consider moral and ethical issues that are embedded in science-related problems in society.
- Exhibit other qualities related to this concentration that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Concentration 6B: Depth of Study in Chemistry

The Concentration in Chemistry includes studies of chemistry substantially beyond those required for general science literacy in Standard 5. The depth and breadth of study in Concentration 6B should be that normally associated with a major in chemistry, and should provide conceptual foundations distributed across the discipline. Integral to the concentration are conceptual foundations that include principles relating to chemical structures, reactivity, reactions, properties and processes of elements, compounds, mixtures, inorganic and organic substances, and the role of energy in chemical structures and processes. Concentration 6B includes in-depth study and laboratory/field experiences in chemistry, achievement of an appropriate level of understanding in mathematics, use of methods employed by scientists in the generation of scientific knowledge, and application of chemistry to societal issues including ethical and moral considerations.

Rationale for Concentration 6B

Holders of the Science Credential with a Concentration in Chemistry will be required to teach a wide variety of courses in their teaching assignments. A thorough coverage of the subject is essential to address the major themes and concepts of the *Science Framework for California Public Schools, Kindergarten through Grade Twelve*. Breadth and depth of understanding in chemistry is necessary for teaching advanced and specialized courses, planning curriculum, selecting appropriate educational materials, offering an effective educational program, and serving as a member of an interdisciplinary team of science teachers. Study and application of appropriate mathematics will enable students to solve scientific problems quantitatively.

Factors to Consider

*When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which **depth studies** in Concentration 6B:*

- Encompass the chemistry specifications for subject matter knowledge and competence on pages 43 and 45.
- Foster each student's use of computers in classroom applications, and encourage students to apply scientific knowledge to everyday experiences and uses of technology.
- Include demonstration of mathematical skills needed to complete studies that are required by advanced courses in chemistry.
- Engage students in decision-making, scientific methods of inquiry, and collaborative and cooperative learning groups.
- Encourage students to apply value-analysis skills and to consider moral and ethical issues that are embedded in science-related problems in society.
- Exhibit other qualities related to this concentration that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Concentration 6C: Depth of Study in Geosciences

The Concentration in Geosciences includes studies of geology substantially beyond those required for general science literacy in Standard 5. The depth and breadth of study in Concentration 6C should be that normally associated with a major in geology, and should provide conceptual foundations that are distributed across the discipline. Integral to the concentration are conceptual foundations that include geology, astronomy/cosmology, meteorology, and oceanography. Concentration 6C includes in-depth study and field/laboratory experiences in the geosciences, achievement of an appropriate level of understanding in mathematics, use of methods that are employed by scientists in the generation of scientific knowledge, and application of geosciences to societal issues including ethical and moral considerations.

Rationale for Concentration 6C

Holders of the Science Credential with a Concentration in Geosciences will be required to teach a wide variety of courses in their teaching assignments. A thorough coverage of the subject is essential to address the major themes and concepts of the *Science Framework for California Public Schools, Kindergarten through Grade Twelve*. Breadth and depth of understanding of the geosciences is necessary for teaching advanced and specialized courses, planning curriculum, selecting appropriate educational materials, providing an effective educational program, and serving as a member of an interdisciplinary team of science teachers. Study and application of appropriate mathematics will enable students to solve scientific problems quantitatively.

Factors to Consider

*When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which **depth studies** in Concentration 6C:*

- Encompass the geosciences specifications for subject matter knowledge and competence on pages 45 and 46.
- Foster each student's use of computers in classroom applications, and encourage students to apply scientific knowledge to everyday experiences and uses of technology.
- Include demonstration of mathematical skills needed to complete studies that are required by advanced courses in geosciences.
- Engage students in decision-making, scientific methods of inquiry, and collaborative and cooperative learning groups.
- Encourage students to apply value-analysis skills and to consider moral and ethical issues that are embedded in science-related problems in society.
- Exhibit other qualities related to this concentration that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Concentration 6D: Depth of Study in Physics

The Concentration in Physics includes studies of physics substantially beyond those required for general science literacy in Standard 5. The depth and breadth of study in Concentration 6D should be that normally associated with a major in physics, and should provide conceptual foundations that are distributed across the discipline. Integral to the concentration are conceptual foundations that include underlying principles of mechanics, heat, electricity and magnetism, wave motion, optics and modern physics. Concentration 6D includes in-depth study and laboratory/field experiences in physics, achievement of an appropriate level of understanding in mathematics, use of methods that are employed by scientists in the generation of scientific knowledge, and application of physics to societal issues including ethical and moral considerations.

Rationale for Concentration 6D

Holders of the Science Credential with a Concentration in Physics will be required to teach a wide variety of courses in their teaching assignments. A thorough coverage of the subject is essential to address the major themes and concepts of the *Science Framework for California Public Schools, Kindergarten through Grade Twelve*. Breadth and depth of understanding in physics is necessary for teaching advanced and specialized courses, planning curriculum, selecting appropriate educational materials, providing an effective educational program, and serving as a member of an interdisciplinary team of science teachers. Study and application of appropriate mathematics will enable students to solve scientific problems quantitatively.

Factors to Consider

*When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which **depth studies** in Concentration 6D:*

- Encompass the physics specifications for subject matter knowledge and competence on pages 46 and 47.
- Foster each student's use of computers in classroom applications, and encourage students to apply scientific knowledge to everyday experiences and uses of technology.
- Include demonstration of mathematical skills needed to complete studies that are required by advanced courses in physics.
- Engage students in decision-making, scientific methods of inquiry, and collaborative and cooperative learning groups.
- Encourage students to apply value-analysis skills and to consider moral and ethical issues that are embedded in science-related problems in society.
- Exhibit other qualities related to this concentration that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 7

Thinking Processes and Shared Values in Science

The program engages students in the use of scientific thinking processes. It provides opportunities for students to understand and develop positive attitudes toward commonly shared scientific values.

Rationale for Standard 7

Science is an active enterprise in which there are continual dynamic interactions between thinking processes and the resulting body of knowledge. Prospective teachers of science must have active experiences with these process skills in order to understand this essential aspect of science.

Since values and attitudes are a vital part of every scientific endeavor, the program should promote commonly shared scientific values, including curiosity, open-mindedness, skepticism and objectivity. Positive attitudes toward quantification, experimentation, verifiability, precision, and proper use of scientific instrumentation should also be fostered by the program.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which the program:

- Requires students to use the science processes of developing questions, observing, communicating, comparing, ordering, categorizing, relating, inferring, applying, and drawing tentative conclusions.
- Requires students to form and test hypotheses based on applicable science theory and information accumulated from experimentation.
- Requires students to demonstrate understanding of cause and effect relationships that govern interactions among objects and events.
- Encourages students to embrace commonly shared values of the scientific community, including earnest curiosity, resolute open-mindedness, healthy skepticism and consistent objectivity.
- Leads students to an understanding of the value and importance of quantification, experimentation, verifiability, accuracy and precision, and proper use of scientific instruments in science.
- Has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 8: Laboratory and Field Experiences

Laboratory and field experiences constitute a significant portion of coursework in the program. Whenever practical, studies of the concepts and information of science are presented through and based on such experiences.

Rationale for Standard 8

Science examines the natural world and cannot be understood without direct experiences with that world. The *Science Framework for California Public Schools, Kindergarten through Grade Twelve* recommends that a substantial portion of instructional time in classroom science programs be spent in laboratory and field experiences. Future teachers need extensive exposure to these activities in their subject matter programs, so they may later incorporate such activities effectively in their teaching.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which:

- A significant portion of the program consists of laboratory and field experience.
- When appropriate, laboratory/field experiences contribute to students' understanding of important science concepts, information, methods and strategies.
- Open-ended and problem-solving experiences are included in the laboratory/field coursework.
- Students analyze and evaluate data collected during laboratory or field experiences, using statistical analysis when appropriate.
- Students are given opportunities to design laboratory experiments and fieldwork, and to evaluate the designs of other students.
- Live organisms are observed, captured and cared for appropriately and lawfully.
- The program has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 9

Science and Technology

The program addresses the interrelationships between science and technology, and examines the impact of technology on society.

Rationale for Standard 9

Science and technology are intimately interwoven. Technology depends on the results of science. Science advances as more sophisticated devices and instruments are produced through technological applications. The products of technology profoundly impact society and the quality of life, often necessitating public decisions about uses of technology. Teachers will need to understand the scientific bases of technology in order to educate future citizens about appropriate applications of technology.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which the program:

- Explains the scientific functions and principles of such technological applications as household appliances, medical instruments, nuclear reactors, and machines and electronic instruments used in transportation, industry and agriculture.
- Addresses the impact of technology and scientific research on the environment and human society.
- Encourages students to recognize that technological developments create new areas of scientific research, which contribute to further developments in technology.
- Acknowledges the impact of technology on a wide range of careers in science and other fields of endeavor.
- Prompts students to examine and confront ethical and moral issues related to the use and impact of technology, and to consider how these issues might be resolved.
- Provides experiences that clarify the interrelationships and applications of scientific and social values, and encourages the application of rational decision-making skills to major issues of concern.
- Has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 10

Safety Procedures in the Program

The program instructs students in proper safety procedures prior to laboratory and field experiences, and includes instruction in emergency procedures and the proper storage, handling and disposal of chemicals and equipment.

Rationale for Standard 10

Recent legislation concerning safety and the handling of chemicals has significantly changed science laboratory and field practices. For science instruction to be conducted in a safe and legally compliant manner in public schools, prospective teachers of science must be instructed properly in matters of safety and emergency procedures.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which the program:

- Orients students to safety procedures that are needed before and during laboratory and field experiences.
- Has facilities that are properly equipped with, and instructs students in, the proper use of safety devices such as eye-wash stations, deluge showers, drench hoses, spill kits, fire extinguishers and fume hoods.
- Includes instruction on the proper storage of chemicals by compatibility categories, hazardous waste storage, and disposal procedures.
- Includes instruction in the toxic, mutagenic, carcinogenic and allergenic nature of certain chemicals.
- Includes instruction in the proper use of high voltage sources, lasers and other specialized equipment.
- Includes instruction on appropriate care, storage and disposal of live and preserved materials.
- The program has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 11

Equity and Diversity in the Program

The subject matter preparation program promotes educational equity by utilizing instructional, advisement and curricular practices that offer equal access to science content and career options for all students. Each student in the program acquires knowledge, understanding and appreciation of the perspectives and contributions of diverse cultural, ethnic and gender groups related to the disciplines of science.

Rationale for Standard 11

Students who attend California schools are increasingly diverse. They live in a society that has benefitted from the perspectives and contributions of men, women, and many cultural and ethnic groups. Prospective teachers must understand and appreciate the cultural perspectives and academic contributions of these groups. They must also be aware of barriers to academic participation and success, and must experience equitable practices of education during their academic preparation.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which:

- In the course of the program, students experience classroom practices and use instructional materials that promote educational equity among diverse learners.
- The program includes faculty role models from diverse cultural and ethnic groups, men and women, and individuals with exceptional needs.
- The program includes faculty who are concerned about and sensitive to diverse cultural and ethnic groups, men, women, and individuals with exceptional needs.
- The institution encourages men and women who are culturally and ethnically diverse to enter and complete the subject matter program.
- Each student learns about the contributions and perspectives of diverse cultural, ethnic and gender groups related to several disciplines of science.
- Students examine ways in which the growth and development of the sciences have affected different cultural, ethnic, gender and handicapped groups.
- Coursework in the program fosters understanding, respect and appreciation of human differences, including cultural, ethnic, gender and language variations.
- The program has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 12

Varied Teaching Strategies in the Program

The program exposes students to a variety of appropriate methods and strategies for teaching, learning and assessing science.

Rationale for Standard 12

Teachers encounter students with differences in learning styles. Observation of and exposure to a wide variety of methods and techniques is important to provide future teachers with a broad base of instructional models from which to draw in the classroom.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which:

- Students encounter a variety of teaching methods and strategies during the program, such as lectures, demonstrations, laboratory and field experiences, computer assisted instruction and computer generated lessons, discussions, group projects, and oral presentations.
- Students experience a variety of evaluation techniques, such as multiple choice questions, free-response questions, oral assessments and performance-based assessments.
- The program has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Category II: Essential Features of Program Quality

Standard 13

Coordination of the Program

Each subject matter preparation program is coordinated effectively by one or more persons who are responsible for program planning, implementation and review.

Rationale for Standard 13

The accomplishments of students in a subject matter preparation program depend in part on the effective coordination of the program by responsible members of the institution's administrative staff and/or academic faculty. For students to become competent in the subjects they will teach, all aspects of their subject matter preparation must be planned thoughtfully, implemented conscientiously and reviewed periodically by designated individuals.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which:

- There is effective communication and coordination among the academic program faculty, and between the faculty and local school personnel, local community colleges, and the professional education faculty.
- One or more persons are responsible for overseeing and assuring the effectiveness of student advisement and assessment in the program (refer to Standards 14 and 15), and of program review and development by the institution (refer to Standard 16).
- Sufficient time and resources are allocated for responsible faculty and/or staff members to coordinate all aspects of the program.
- The program has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 14

Student Advisement and Support

A comprehensive and effective system of student advisement and support provides appropriate and timely program information and academic assistance to students and potential students, and gives attention to transfer students and members of groups that traditionally have been underrepresented among teachers of science.

Rationale for Standard 14

To become competent in a discipline of study, students must be informed of the institution's expectations, options and requirements; must be advised of their own progress toward academic competence; and must receive information about sources of academic and personal assistance and counseling. Advisement and support of prospective teachers are critical to the effectiveness of subject matter preparation programs, particularly for transfer students and members of groups that traditionally have been underrepresented in the discipline. In an academic environment that encourages learning and personal development, prospective teachers acquire a student-centered outlook toward education that is essential for their subsequent success in public schools.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which:

- Advisement and support in the program are provided by qualified individuals who are assigned those responsibilities, and who are available and attentive when the services are needed.
- Advisement services include information about course equivalencies, financial aid options, admission requirements in professional preparation programs, state certification requirements, field experience opportunities, and career opportunities.
- Information about program purposes, options and requirements is available to prospective students and distributed to enrolled students.
- The institution encourages students to consider careers in teaching, and attempts to identify and advise interested individuals in appropriate ways.
- The institution actively seeks to recruit and retain students who are members of groups that traditionally have been underrepresented among science teachers.
- The institution collaborates with community colleges to articulate academic curricula and to facilitate the transfer of students into the subject matter program.
- The program has a process for evaluating non-college work experience, and to equate it (as appropriate) with subject matter requirements in the program.
- The program has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 15

Assessment of Subject Matter Competence

The program uses multiple measures to assess the subject matter competence of each student formatively and summatively in relation to Standards 1 through 11. The scope and content of each student's assessment is congruent with the studies the student has completed in the program.

Rationale for Standard 15

An institution that offers content preparation for prospective teachers has a responsibility to verify their competence in the subject(s) to be taught. It is essential that the assessment in science use multiple measures, have formative and summative components, and be as comprehensive as Standards 1 through 11. Its content must be congruent with each student's studies of general science, breadth and depth in the program (in accordance with Standards 3-6). Course grades and other course evaluations may be part of the assessment, but may not comprise it entirely.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which:

- The assessment process includes a variety of approaches, such as student performances, presentations, projects, portfolios, observations and interviews, as well as oral and written examinations based on criteria established by the institution.
- The assessment encompasses Standards 1-11, and is congruent with each student's breadth and concentration studies in the program (Standards 3-6).
- The assessment encompasses the content domains and assesses the content skills that are outlined in the *Specifications for the Subject Matter Knowledge and Competence of Prospective Teachers of Science* on pages 35-47 of this handbook.
- The assessment process is valid, reliable, equitable, and fair, and includes provisions for student appeals.
- The scope, process and criteria for assessment are clearly delineated and made available to students.
- The institution makes and retains thorough records regarding each student's assessment performances.
- The assessment process is periodically evaluated to ensure its quality, fairness and effectiveness.
- The program has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Standards for Science Teacher Preparation

Standard 16

Program Review and Development

Each subject matter program has a comprehensive, ongoing system of review and development that involves faculty, students and appropriate public school personnel, including science teachers, and that leads to continuing improvements in the program.

Rationale for Standard 16

The continued quality and effectiveness of subject matter preparation depends on periodic reviews and improvements of programs. Program development and improvement should be based in part on the results of systematic, ongoing reviews that are designed for this purpose. Reviews should be thorough, and should include multiple kinds of information from diverse sources.

Factors to Consider

When reviewers judge whether a program meets this standard, the Commission expects them to consider the extent to which:

- Systematic and periodic reviews of the subject matter program reexamine its philosophy, purpose, design, curriculum and intended outcomes for students.
- Information is collected about the program's strengths, weaknesses and needed improvements from participants in the program, including faculty, students, recent graduates, and employers of recent graduates, and from other appropriate public school personnel, including teachers of science.
- Program development and review involves consultation among departments that participate in the program, including subject matter and education departments, and includes review of recommendations by elementary, secondary and community college educators.
- Program improvements are based on the results of periodic reviews, the implications of new knowledge about the subject(s) of study, and the identified needs of program students and school districts in the state.
- Assessments of students (pursuant to Standard 15) are reviewed and used (in the aggregate) for improving the philosophy, design, curriculum and/or outcome expectations of the program.
- The program has other qualities related to this standard that are brought to the reviewers' attention by the institution.

Specifications for the Subject Matter Knowledge and Competence of Prospective Teachers of Science

Science Teacher Preparation and Assessment Advisory Panels Commission on Teacher Credentialing 1992

A student who seeks to earn the Single Subject Teaching Credential in Science should have a basic knowledge of biological sciences, chemistry, geosciences *and* physics. The student should also be well acquainted with the underlying interrelationships among the sciences, and must have a depth of scientific knowledge and skill in one of the four concentration areas.

To verify that these competence expectations have been attained, the Commission has developed and adopted a battery of subject matter assessments in science that consist of two sections in each concentration area: a two-hour knowledge examination (multiple-choice questions) and a two-hour performance assessment (constructed-response problems). The Science Teacher Preparation and Assessment Advisory Panel drafted the following specifications for the scope and content of the two sections of the assessment. The specifications illustrate the science knowledge, skills and abilities that students should acquire and develop in a subject matter program for future science teachers.

Science Competence Specifications: General Structure

Each prospective teacher of science should be broadly competent across the four science emphasis areas, and should have in-depth competence in one area of concentration. Future teachers who attempt to qualify for the Single Subject Credential by passing the Commission's new standardized assessments in science must pass (1) a General Science Component which is common to all examinees and comprises 60% of the assessment, and (2) a Concentration Component in one of the four science concentrations, which comprises 40% of the assessment.

For the common General Science Component and the four Concentration Components, the Science Teacher Advisory Panel drafted (1) content outlines and (2) performance expectations. The content outlines define the scope and content of the knowledge and skill domains to be included in the two-hour knowledge exam as well as the two-hour performance assessment. The former exam measures knowledge of concepts, principles and issues across the scope of the content outline. The performance assessment measures higher-order abilities: organize and retrieve information, process and interpret data, understand and explain complex phenomena, and communicate effectively.

Taken together, the standardized assessments encompass the following dimensions of competence in science:

- (1) Scientific Content: The assessments examine knowledge of fundamental scientific concepts, principles, phenomena and interrelationships. The specific content of the General Science Component and the Concentration Component are detailed in the content outlines that follow.

Specifications: Subject Matter Knowledge and Competence of Science Teachers

- (2) Levels of Cognition: The assessments focus on cognitive levels that are defined according to Bloom's Taxonomy. The following chart shows the approximate percentages of questions within each level of the taxonomy.

	Percentages in General Science Component	Percentages in Emphasis Components
• Knowledge of Terminology (included in the other levels)		
• Comprehension-Level Questions	40	20
• Application-Level Questions	40	30
• Analysis-Level Questions		20
• Synthesis-Level Questions	20	20
• Evaluation-Level Questions		10

- (3) Methods and Processes of Science: Questions in the assessments require prospective teachers to demonstrate an understanding of the methods and processes of science. A major goal of science education is that students develop an understanding of science as a complex human enterprise with a distinct philosophy and methodology. Questions and problems in the assessments are therefore *set in the context of* one or more of the following aspects of current scientific methodology.

- Problem identification.
- Experimental design, especially the selection and control of variables.
- Use of theoretical and physical models.
- Formulation and testing of hypotheses.
- Measurement and observation, including the use of instruments.
- Data analysis and evaluation.

Following are the specifications by the Science Teacher Advisory Panel regarding the competence of future science teachers in general science and the four emphasis areas.

General Science Competence Expectations for All Prospective Science Teachers (Common Core of Scientific Knowledge and Skill)

The most important expectations for the competence of prospective teachers of science are related to *the general science core* because each future teacher's knowledge base must be sufficient to impart scientific literacy to secondary students in each broad area of science: biology, chemistry, geoscience, and physics. This common core of knowledge and skill in science should include *interdisciplinary concepts and skills* because all future teachers of science will be expected to implement the new California Science Curriculum Framework, which requires an understanding of the interrelationships among the sciences. To fulfill these assignments well, prospective science teachers must have a general understanding of all the sciences and their underlying commonalities. While a future teacher is expected to have *extensive expertise* in only one of the four content areas, he or she should be able to respond to fundamental questions involving concepts from several areas of science simultaneously.

Specifications: Subject Matter Knowledge and Competence of Science Teachers

In the Commission's standardized assessments for credential candidates, sixty percent (60%) of the questions comprise the General Science Component that is administered to all examinees. In this component, the questions are distributed as follows among the areas of science: 15% in life science, 10% in chemistry, 10% in geoscience, 10% in physics, and 15% in general issues in science. The following content outline defines the scope and substance of the General Science Component of the standardized assessments. The outline also illustrates the extent and content of competence that the Commission expects of each applicant for the Single Subject Credential in Science.

Content Outline for General Science Competence

I. Life Science (15%)

- A. Molecular and Cellular Biology
 - 1. Molecular and cellular biology
 - 2. Structure and function of cells
 - 3. Cellular bioenergetics
 - 4. Molecular biology of genes and gene function
- B. Biology of Organisms
 - 1. Characteristics of life and life forms
 - 2. Plants, animals – including emphasis on humans
 - 3. Principles of Mendelian genetics
- C. Ecology
 - 1. Population growth
 - 2. Species/Populations interactions
 - 3. Community energetics and characteristics
 - 4. Biogeochemical cycles
 - 5. Interrelationships among ecosystems
- D. Evolution
 - 1. Evolutionary mechanisms
 - 2. Evolutionary patterns
 - a. Adaptation and fitness
 - b. Population genetics and micro-evolutionary change
 - c. Speciation and macro-evolutionary change
 - 3. History of life on earth

II. Chemistry (10%)

- A. Structure and Stability
 - 1. States of matter - including models of gases, liquids and solids
 - 2. Models of atomic, molecular, and ionic structures
 - 3. Polarity and implications for properties of molecules
 - 4. Simple nuclear chemistry including radioactivity, fission, and fusion
 - 5. Simple models for chemical bonds - including implications for properties and geometries of molecules
- B. Chemical Reactions
 - 1. Types of reactions
 - a. Phase changes
 - b. Acid-base
 - c. Organic functional group reactions
 - 2. Stoichiometry - including the use of mole
 - 3. Solutions - concentrations, vapor pressure, osmosis, diffusion
 - 4. Rates
 - a. Qualitative effects of temperature and concentration
 - b. Concept of activation energy
 - c. Simple collision model for reactions
 - 5. Energy changes including calorimetry

III. Geosciences (10%)

- A. Astronomy
 - 1. The Solar System/planetary systems
 - 2. Stars, galaxies
 - 3. Cosmology
- B. Geology
 - 1. Earth materials and natural resources
 - 2. Geomorphic and internal processes
 - 3. Natural hazards and environmental issues
 - 4. The Earth's interior, plate tectonics
 - 5. The history of the Earth and its life forms
- C. Meteorology
 - 1. Atmospheric composition
 - 2. Atmospheric transport
 - 3. Weather and climate
- D. Oceanography
 - 1. Physical characteristics of the ocean
 - 2. Chemical characteristics of the ocean
 - 3. Biological characteristics of the ocean
 - 4. Geological components of the ocean
 - 5. Air/Sea interactions

IV. Physics (10%)

- A. Energy - Mechanics
 - 1. Motion
 - a. Linear, curvilinear, periodic
 - b. Simple machines and pendulums
 - 2. Dynamics - including force, torque, and Newton's laws
 - 3. Conservation principles of momentum and energy
 - 4. Gravity
- B. Energy - Heat
 - 1. Mechanical equivalence - transfer of energy, friction, and heat pumps
 - 2. Temperature and thermal energy
 - 3. Transfer mechanisms - conduction, convection, radiation
 - 4. Effects on materials- expansion and contraction
- C. Energy - Electricity and Magnetism
 - 1. Static electricity and DC circuits
 - 2. Magnetism - polarity and fields
- D. Wave Motion
 - 1. Reflections
 - 2. Vibrations in matter (sound)
 - 3. Electromagnetic radiation - spectra, visible light, and color
 - 4. Optics including geometric ray diagrams
- E. Atomic and Nuclear Physics
 - 1. Common subatomic particles - neutron, proton, electron, and neutrino
 - 2. Strong and weak interactions
 - 3. Effects of ionizing radiation

V. General Issues of Science (15%)

- A. History and Philosophy of Science
- B. Ethics of Science and Technology¹
- C. Social Impact of Technology (STS)
- D. Technological Applications
- E. Safety
- F. Cultural and Individual Contributions

- G. Linkages/Integration between the various fields of science
Examples of topics in this category are:
 - Interaction of electromagnetic radiation with molecules
 - Enzymes
 - The atmosphere - pollution
 - The atmosphere - global effects (greenhouse, ozone layer destruction)
 - Photosynthesis and respiration
 - Water cycle, pollution and resources
 - Physiology and physics of athletics
 - Cosmochemistry
 - Evidence for age and history of the earth - radioactivity, stratigraphy, fossils, magnetism of rocks, geochemistry, atmospheric composition

1 In the Content Area Performance Assessment in General Science, the criteria for scoring answers to questions about the ethics of science and technology focus on the quality of the examinee's response to the questions (justification, thoughtfulness, thoroughness, etc.), rather than the ethical positions expressed by the examinees.

Performance Expectations for General Science Competence

The content outline for general science competence (above) suggests the breadth of each prospective teacher's knowledge about science concepts, principles and issues. A future instructor's competence must also go beyond knowledge, to include conceptual skills as indicated in the following matrix. Each prospective teacher should demonstrate scientific skills in the contexts that are identified along the top of the matrix. The left column identifies the sciences in which these skills should be demonstrated.

Skill or Context	Models, Systems, Concepts and Patterns	Data Analysis, Experimental Design, and Investigations	Science, Technology and Society
Content Domains			
Life Science			
Chemistry			
Geoscience			
Physics			

The expected skills in general science go beyond a general comprehension of data and the ability to explain concepts. Each prospective teacher is expected to demonstrate higher cognitive skills in each science area. The science content for these skills is to be drawn from the content outline (above) for general science competence.

In the standardized assessments developed and adopted by the Commission, each examinee is expected to be prepared to respond skillfully and competently to ordinary problems, questions and exercises represented by the twelve cells in the above matrix. Although each form of the assessment does not include twelve constructed-response problems, each form *does* include at least one problem, task or exercise in each column of the matrix, and at least one in each row of the matrix.

Competence in a Science Concentration Area for Each Prospective Science Teacher (Depth of Scientific Knowledge and Skill)

Beyond the broad knowledge of science that all science teachers are expected to possess, each teacher also needs to select a concentration area for advanced study. In the concentration, the teacher's content knowledge and skills should have sufficient depth to enable him/her to design and critique scientific inquiries, make sound curriculum plans, and select teaching methods that foster the scientific accomplishments of all students in departmentalized science classes.

In the Commission's standardized assessments for credential candidates, forty percent (40%) of each examinee's questions focus on his/her concentration area in life science, chemistry, geoscience, or physics. Following are the four content outlines that define the scope and substance of the four Concentration Components of the standardized assessments. The outlines also suggest the extent and content of competence that the Commission expects of applicants for the Single Subject Credential in Science.

Content Outline for the Concentration in Biological Sciences

- I. Molecular and Cellular Biology
 - A. Biologically important molecules, structure and function
 - 1. Carbohydrates
 - 2. Lipids
 - 3. Proteins
 - 4. Nucleic Acids
 - B. Structure and function of cells
 - 1. Prokaryotic vs. eukaryotic cells
 - 2. Organelle structure and function
 - 3. Cell membranes
 - 4. Transport mechanisms: osmosis, diffusion, active transport
 - 5. Cellular reproduction: mitosis & meiosis
 - C. Cellular bioenergetics
 - 1. Principles of enzyme action and biosynthesis
 - 2. Respiration, anaerobic and aerobic
 - 3. Photosynthesis
 - 4. Chemosynthesis
 - D. Molecular biology of genes and gene function
 - 1. DNA and RNA structure
 - 2. DNA replication
 - 3. Transcription
 - 4. Translation
 - 5. Regulation of gene action
 - 6. Recombinant DNA technology
 - 7. Viruses (example: reverse transcriptase encapsulated protein)
- II. Biology of Organisms
 - A. Characteristics of life and life forms
 - 1. Bacteria
 - 2. Protists
 - 3. Fungi
 - 4. Plants
 - 5. Animals
 - B. Organ system biology (with a balance of items about plants, animals and humans)
 - 1. Reproduction, growth, development (includes embryology and differentiation)
 - 2. Nutrition
 - 3. Transport
 - 4. Integration and control: nervous, hormonal, feedback mechanisms, homeostasis
 - 5. Waste removal
 - 6. Support: structures and movement
 - 7. Gas exchange
 - 8. Defense mechanisms including plants and animals
 - C. Principles of Genetics
 - 1. Dihybrid crosses
 - 2. Multiple alleles, linkage
 - 3. Expressivity
 - 4. Human heredity and genetic disorders

III. Ecology

- A. Population Dynamics
 - 1. Population growth- carrying capacity, equilibrium
 - 2. Intraspecific competition
- B. Life History Patterns
 - 1. Reproductive strategies
 - 2. Survivorship: r & k selection
- C. Species/Populations Interactions
 - 1. Predator-Prey, including parasitism
 - a. cycles
 - b. strategies & defenses
 - 2. Mutualism, commensalism
 - 3. Interspecific competition
- D. Community Energetics
 - 1. Food webs
 - 2. Productivity and measurement
- E. Biogeochemical cycles
 - 1. Decomposer organisms
 - 2. Nutrient recycling
 - 3. Nitrogen fixation
- F. Community Characteristics
 - 1. Succession
 - 2. Diversity
 - 3. Stability-disturbances
- G. Interrelationships among ecosystems

IV. Evolution

- A. Evolutionary mechanisms
 - 1. Sources of variation (mutation, genetic recombination)
 - 2. Darwinism, neodarwinism and current evolutionary models (neutral genes, relaxed selection, punctualism)
- B. Evolutionary patterns
 - 1. Adaptation & fitness
 - 2. Population genetics and microevolutionary change
 - a. Hardy-Weinberg equilibrium
 - b. Genetic drift, gene flow and nonrandom reproduction
 - 3. Speciation and macroevolutionary change
 - a. Species concept and speciation processes
 - b. Evidence for macroevolutionary change
 - c. Punctuated equilibrium and rates of evolutionary change
 - d. Adaptive radiation
 - e. Parallel evolution, mimicry, coevolution
- C. History of life
 - 1. Origin of life
 - 2. Early life: origin of photosynthesis and eukaryotic cells
 - 3. Diversity of life forms and evolutionary basis for classification
 - 4. Taxonomic groups and phylogenetic relationships, e.g: Annelids, Mollusks & Arthropods; Mosses, Conifers, Flowering Plants
 - 5. Human evolution

Performance Abilities for the Concentration in Life Science

The content outline for the concentration in life science (above) suggests the breadth of each prospective teacher's knowledge about biological concepts, principles and issues. The concentration also includes conceptual skills as indicated in the following matrix. Each prospective teacher should demonstrate scientific skills in the contexts that are identified along the top of the matrix. The left column identifies the content domains in which these skills should be demonstrated.

Skills/Contexts	Models, Systems, and Concepts	Data Analysis, Experimental Design, and Investigations	Science, Technology and Society
Content Domains			
Cellular and Molecular			
Genetics and Evolution			
Organismal and Ecology			

The expected skills in the life science concentration go beyond a general comprehension of data and the ability to explain concepts. Each prospective teacher with a concentration in life science is expected to demonstrate higher cognitive skills in each content domain in the matrix. In the standardized assessment, the specific content for these skills is drawn from the content outline (above) for the life science concentration.

In the standardized assessment developed and adopted by the Commission, each examinee with a concentration in life science should be prepared to respond skillfully and competently to advanced problems, questions and exercises represented by the twelve cells in the above matrix. Although each form of the assessment does not include twelve constructed-response problems in life science, each form *does* include at least one problem, task or exercise in each column and at least one in each row of the matrix.

Content Outline for the Concentration in Chemistry

- I. Chemistry
 - A. Principles underlying the conditions governing chemical reactions.
 1. Chemical equilibrium
 - a. Gases
 - b. Aqueous solutions
 2. Electrochemistry
 3. Thermochemistry
 - a. Specific heat and heat capacity
 - b. Calorimetry
 - c. Heat of reactions, enthalpy
 - d. Spontaneity of reactions
 4. Reaction kinetics

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- B. Qualitative and quantitative treatment of chemical systems, reactions and solutions
 - 1. Reaction types (Single replacement, double replacement, synthesis, decomposition)
 - 2. Acids, bases, and salts
 - 3. Redox reactions
 - 4. Organic reactions
 - Functional group behavior
 - Simple reactions
 - Polymerization
 - 5. Solution Chemistry and Colligative Properties
 - 6. Kinetic Molecular Theory
 - a. Gas laws
 - b. Phase changes and phase diagrams
- C. Chemical structure
 - 1. Quantum Model of the atom
 - 2. Chemical Bonding
 - a. Valence
 - b. Physical properties resulting from different bonding types
 - c. Geometry systematics and predicative models (e.g: VSEPR)
- D. Nuclear Chemistry
 - 1. Simple nuclear structure model
 - 2. Energy relations in nuclear reactions and radioactive decay
 - 3. Benefits and hazards of use of radiation and radioactivity
- E. Applications

Performance Abilities for the Concentration in Chemistry

The content outline for the concentration in chemistry (above) suggests the breadth of each prospective teacher's knowledge about chemical concepts, principles and issues. The concentration also includes conceptual skills as indicated in the following matrix. Each prospective teacher should demonstrate scientific skills in the contexts that are identified along the top of the matrix. The left column identifies the content domains in which these skills should be demonstrated.

<u>Skills/Contexts</u>	Models, Systems, Patterns, and Concepts	Data Analysis, Experimental Design, and Investigations
Content Domains		
Structure/Property Correlations		
Chemical Reactions		

The expected skills in the chemistry concentration go beyond a general comprehension of data and the ability to explain concepts. Each prospective teacher with a concentration in chemistry is expected to demonstrate higher cognitive skills in each content domain in the matrix. The specific content for these skills is drawn from the content outline (above) for the chemistry concentration.

In the standardized assessments developed and adopted by the Commission, each examinee with a concentration in chemistry is expected to be prepared to respond skillfully and competently to advanced problems, questions and exercises represented by the twelve cells in the above matrix. Although each form of the assessment does not include twelve constructed-response problems in chemistry, each form *does* include at least one problem, task or exercise in each column and each row of the matrix. In addition, each form of the exam in chemistry includes one problem dealing with the impact of chemistry on technology and society.

Content Outline for the Concentration in Geosciences

I. Geosciences

- A. Astronomy/cosmology
 1. The history and methods of astronomy
 2. Planetary motions
 3. Planets and their satellites
 4. Asteroids, meteoroids, and comets
 5. The sun, Earth, Moon
 6. Properties of stars, stellar evolution
 7. Interstellar matter, galaxies, quasars
 8. The origin of the solar system and the universe
- B. Geology
 1. Geologic time and the history of the Earth
 2. Minerals
 3. Igneous activity, igneous rocks
 4. Metamorphism, metamorphic rocks
 5. Weathering, sedimentary rocks
 6. Common fossil groups and their evolution
 7. Erosion, transportation, and deposition by mass movement, streams, underground water, glaciers, wind, waves and currents
 8. Geologic structures, Earthquakes
 9. Major surface features of the Earth
 10. The interior of the Earth, plate tectonics
 11. Environmental geology
- C. Meteorology
 1. The composition of the atmosphere
 2. Clouds, precipitation, the hydrologic cycle
 3. Atmospheric circulation
 4. Storms and severe weather events
 5. Climatology, short and long term climate change, human interaction
- D. Oceanography
 1. The chemical and physical properties of water
 2. The origin of the Earth, its oceans, and the life in the oceans
 3. Global plate tectonics and the ocean basins
 4. Air/sea interactions, vertical and horizontal ocean circulation, waves and tides
 5. Oceanography of coastal waters, marginal seas, estuaries
 6. Human interaction with the ocean, marine pollution, long term sea-level changes
- E. Applications

Performance Abilities for the Concentration in Geosciences

The content outline for the concentration in geosciences (above) suggests the breadth of each prospective teacher's knowledge about geoscience concepts, principles and issues. The concentration also includes conceptual skills as indicated in the following matrix. Each prospective teacher should demonstrate scientific skills in the contexts that are identified along the top of the matrix. The left column identifies the content domains in which these skills should be demonstrated.

Skills/Contexts	Models, Systems, Patterns, and Concepts	Data Analysis, Experimental Design, and Investigations
Content Domains		
Geology		
Astronomy/ Meteorology/ Oceanography		

The expected skills in the geoscience concentration go beyond a general comprehension of data and the ability to explain concepts. Each prospective teacher with a concentration in geosciences is expected to demonstrate higher cognitive skills in each content domain in the matrix. The specific content for these skills is drawn from the content outline (above) for the geoscience concentration.

In the standardized assessments developed and adopted by the Commission, each examinee with a concentration in geosciences is expected to be prepared to respond skillfully and competently to advanced problems, questions and exercises represented by the twelve cells in the above matrix. Although each form of the assessment does not include twelve constructed-response problems in geosciences, each form *does* include at least one problem, task or exercise in each column of the matrix, and at least one in each row of the matrix. In addition, each form of the assessment in geosciences includes one problem dealing with the impact of geosciences on technology and society.

Content Outline for the Concentration in Physics

- I. Physics
 - A. Mechanics
 1. Conservation Principles: momentum and energy
 2. Gravitation: force and fields
 - B. Heat
 1. Mechanical equivalence: friction, heat engines
 2. Thermodynamic Principles
 - a. Heats of fusion & vaporization
 - b. Heat capacity
 - c. Entropy
 - d. Enthalpy

Specifications: Subject Matter Knowledge and Competence of Science Teachers

- C. Electricity and Magnetism
 1. Static electricity: charge, field, potential
 2. Current electricity: AC and DC circuits
 3. Magnetism: polarity and fields
- D. Wave Motion
 1. Properties and models: transmission, refraction, diffraction, interference
 2. Electromagnetic radiation: spectra, visible light, color
- E. Modern Physics
 1. Quantum Theory
 2. Subatomic particles
 3. Relativity
- F. Applications

Performance Abilities for the Concentration in Physics

The content outline for the concentration in physics (above) suggests the breadth of each prospective teacher's knowledge about physical concepts, principles and issues. The concentration also includes conceptual skills as indicated in the following matrix. Each prospective teacher should demonstrate scientific skills in the contexts that are identified along the top of the matrix. The left column identifies the content domains in which these skills should be demonstrated.

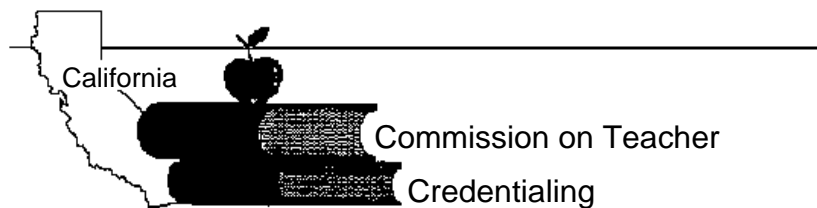
<u>Skills/Contexts</u>	Models, Systems, Patterns, and Concepts	Data Analysis, Experimental Design, and Investigations
Content Domains		
Matter and Energy		
Fields and Waves		

The expected skills in the physics concentration go beyond a general comprehension of data and the ability to explain concepts. Each prospective teacher with a concentration in physics is expected to demonstrate higher cognitive skills in each content domain in the matrix. The specific content for these skills is drawn from the content outline (above) for the physics concentration.

In the standardized assessments developed and adopted by the Commission, each examinee with a concentration in physics is expected to be prepared to respond skillfully and competently to advanced problems, questions and exercises represented by the twelve cells in the above matrix. Although each form of the assessment does not include twelve constructed-response problems in physics, each form *does* include at least one problem, task or exercise in each column of the matrix, and at least one in each row of the matrix. In addition, each form of the assessment in physics includes one problem dealing with the impact of physics on technology and society.

Part 3

Implementation of Science Teaching Standards



Implementation of Program Quality Standards for Subject Matter Preparation in Science

The Program Quality Standards for Subject Matter Preparation in Science are part of a broad shift in the policies of the Commission on Teacher Credentialing related to the preparation of professional teachers and other educators in California colleges and universities. The Commission initiated this policy change to foster greater excellence in educator preparation and to combine flexibility with accountability for institutions that offer programs for prospective teachers. The success of this reform effort depends on the effective *implementation* of program quality standards for each credential.

Pages 49 through 52 of the handbook provide general information about the transition to program quality standards for all teaching credentials. Then the handbook provides specific information about implementation of the science standards (pp. 53-62).

Transition to Quality Standards for All Teaching Credentials

The Commission is gradually developing and implementing Standards of Program Quality and Effectiveness for all teaching credentials. For subject matter programs, this process began in 1986, with the appointment of an expert advisory panel in elementary education, which was asked to develop *Standards of Program Quality for the Subject Matter Preparation of Elementary Teachers*. In 1988 the Commission adopted these standards for the Multiple Subjects Teaching Credential. The standards have now been implemented in 55 colleges and universities, which offer a total of 64 programs.

In 1989, the Commission established five subject matter advisory panels to develop standards for the subject matter preparation of prospective secondary teachers in English, mathematics, life science, physical science and social science. The panels consisted of subject matter experts from throughout California: K-12 teachers of the subjects, public school curriculum specialists, university professors of the subjects, and other subject matter specialists.

In 1991 the Commission established four more panels to develop program standards in art, music, foreign languages and physical education. Draft standards developed by these panels are being reviewed by colleges, universities, professional organizations, and local and state education agencies, prior to being completed by the panels and adopted by the Commission. Implementation of these standards will follow a timeline similar to the milestones displayed on page 56 below.

In 1993, the Commission plans to appoint advisory panels to develop program standards in business education, health education, home economics, and industrial technology. Initial drafts of standards in these subjects will be distributed widely for discussion and comment before they are completed by the panels and adopted by the Commission. Again, implementation will follow a timeline like that on page 56.

Alignment of Program Standards and Performance Assessments

The Teacher Preparation and Licensing Act of 1970 (Ryan Act) established the requirement that candidates for teaching credentials verify their knowledge of the subjects they intend to teach. Candidates for teaching credentials may satisfy the subject matter requirement by completing approved subject matter programs or passing subject matter assessments that have been adopted by the Commission. The Commission is concerned that the scope and content of the subject matter assessments be aligned and congruent with the program quality standards in each subject.

To achieve this alignment and congruence in science, the Commission asked the Science Teacher Preparation and Assessment Advisory Panel to develop subject matter assessment specifications that would be consistent in scope and content with the program quality standards in this handbook. Following extensive discussion and review, the Commission adopted a detailed set of *Specifications for the Assessment of Subject Matter Knowledge and Competence of Prospective Teachers of Science*, which are in pages 41-45. College and university faculty and administrators are urged to examine these specifications as a source of ideas and information about science content that is important to include in subject matter programs.

The Commission seeks to align the assessment specifications with the program standards in each subject area. Each subject matter advisory panel is asked to develop standards and specifications that are as congruent with each other as possible, to maximize the equivalence between credentials that are earned by completing programs and ones that are earned by passing examinations.

Validity and Authenticity of Subject Matter Assessments

The Commission is also concerned that the subject matter assessments of prospective teachers address the full range of knowledge, skills and abilities needed by teachers of each subject. For fifteen years the Commission relied on subject matter examinations that consisted entirely of multiple-choice questions. In 1987-88, the Commission evaluated fifteen of these subject matter exams comprehensively. More than 400 teachers, curriculum specialists and university faculty examined the specifications of these tests, as well as the actual test questions. An analysis of the reviewers' aggregated judgments showed that (1) particular changes were needed in each multiple-choice test, and (2) each multiple-choice test should be supplemented by a performance assessment in the subject.

Since 1988, the Commission's subject matter advisory panels have created Content Area Performance Assessments (CAPAs) for each of ten Single Subject Credentials. The CAPAs consist of problems, questions and exercises to which examinees construct complex responses, instead of selecting an answer among four given answers. Examinees' responses are scored on the basis of specific criteria (see pp. 44-45) that were created by the advisory panels and are administered by subject specialists who are trained in the scoring process. Candidates for the ten Single Subject Credentials must pass a CAPA as well as a multiple-choice test of their subject matter knowledge, unless they complete an approved subject matter program. Meanwhile, for the Multiple Subject Credential, the Commission has developed and adopted a new exam (the MSAT) that consists of a Breadth of Knowledge Examination (2 hours) and a Content Skills Assessment (3 hours). By developing and adopting the CAPA and MSAT assessments, the Commission has committed itself to assessing the subject matter knowledge and competence of prospective teachers as authentically and comprehensively as possible.

New Terminology for "Waiver Programs"

In enacting the Ryan Act, the Legislature clearly regarded the successful passage of an adopted examination as the principal way to meet the subject matter requirement. However, the law also allowed candidates to complete Commission-approved subject matter programs to "waive" the examination. Because of this terminology in the 1970 statute, subject matter programs have commonly been called "waiver programs" throughout California.

In reality, the law established two alternative ways for prospective teachers to meet the subject matter requirement. An individual who completes an approved subject matter program is not required to pass the subject matter examination, and an individual who achieves a passing score on an adopted exam is not required to complete a subject matter program. Overall, the two options are used by approximately equal numbers of candidates for initial teaching credentials. Subject matter programs are completed by more than half of the candidates for Single Subject Credentials, but the adopted examination is the preferred route for more than half of all Multiple Subject Credential candidates.

Because of the significant efforts of the Commission and its expert advisory panels, subject matter programs and examinations are being made as parallel and equivalent to each other as possible. The term "waiver programs" does not accurately describe a group of programs that are *alternatives to* subject matter examinations. For this reason, the Commission uses the term "subject matter programs" instead of "waiver programs," which is now out of date.

Improvements in the Review of Subject Matter Programs

Some individuals who are involved in the subject matter preparation of prospective teachers will recall the subject matter program reviews that were done by "Waiver Program Panels" for the Commission beginning in 1983. Although there are some similarities between the "old" policies and the plan for implementing the "new" standards in this handbook, there are also some major changes.

- (1) The standards are much broader than the prior guidelines for subject matter programs. The standards provide considerably more flexibility to institutions.
- (2) As a set, the standards are more comprehensive in addressing the quality of subject matter preparation. They provide a stronger assurance of excellent preparation.
- (3) The new Program Review Panels conduct more intensive reviews that focus on program quality issues rather than course titles and unit counts.
- (4) The new panels have more extensive training because the standards require that they exercise more professional discretion regarding the quality of programs.
- (5) Institutional representatives meet with the Review Panels to discuss questions about programs and standards. Improved communications lead to better decisions.

The Commission welcomes comments and suggestions about the program review process, which should be addressed to the Executive Director.

Ongoing Review and Approval of Subject Matter Programs

After the Commission grants full or interim approval to subject matter programs, the programs will be reviewed at six-year intervals, in approximately the same way as the Commission reviews professional preparation programs in California universities and colleges. Periodic reviews will be based on the Standards of Program Quality and Effectiveness. Like professional preparation programs, subject matter programs will be reviewed onsite by small teams of trained reviewers. Reviewers will acquire information about program quality from institutional documents, and from interviews with program faculty, administrators, students, and recent graduates. Prior to each review, the Commission will provide detailed information about its scope, methodology, potential benefits and other implications for the college or university.

Review and Improvement of Subject Matter Standards

Beginning in 1997-98 the Commission will begin a cycle of review and reconsideration of the *Standards of Quality and Effectiveness for Subject Matter Programs in Science* and in other subjects. The standards will be reviewed and reconsidered in relation to changes in academic disciplines, school curricula, and the backgrounds and needs of California students (K-12). Reviews of program standards will be based on the advice of subject matter teachers, professors and curriculum specialists. Prior to each review, the Commission will invite interested individuals and organizations to participate in it. If the Commission modifies the science standards, an amended handbook will be forwarded to each institution with an approved program.

Science Teacher Preparation: Adoption and Implementation of Standards by the Commission

The Science Teacher Preparation Advisory Panel completed its work on the Standards of Program Quality and Effectiveness in 1991. The Commission was prepared to adopt and implement the panel's work, but was concerned about the fiscal impact of the standards during a budget crisis. On November 8, 1991, the Commission adopted the standards, but continued to be concerned about their potential fiscal impact on colleges and universities. Commissioners directed the staff to monitor the crisis and present a plan for implementing the standards in ways that would be fiscally feasible for institutions.

The budgets of postsecondary institutions continued to decline during 1992. On October 1, 1992, the Commission's professional staff recommended an implementation plan for the standards that would accommodate the fiscal crisis in two ways. First, the implementation timeline was "moved back" in time, to allow institutions to begin to recover, if possible, from recent budget reductions. Second, the plan offered two ways for institutions to respond to the standards, depending on local fiscal conditions. On October 2, 1992, the Commission adopted this implementation plan, which appears on the following page. The implementation timeline is summarized on page 55, and diagrammed on 56.

Implementation Timeline: Impact on Candidates for Science Credentials

Candidates for Single Subject Credentials in Science who do not plan to pass the Commission-adopted subject matter examinations should enroll in subject matter programs that fulfill the "new" standards either (1) once a new program at their institution commences, or (2) by January 1, 1995, whichever occurs first. After a new program begins at an institution, no students should enroll for the first time in an "old" program (i.e., one approved under "old" guidelines). Regardless of the date when new programs are implemented, no students should enter old programs after January 1, 1995.

Candidates who enrolled in programs approved on the basis of pre-1991 guidelines ("old" programs) may complete those programs provided that (1) they entered the old programs either before new programs were available at their institutions, or before January 1, 1995, and (2) they complete the old programs before January 1, 1998.

Candidates who do not comply with these timelines may qualify for Single Subject Teaching Credentials by passing the subject matter examinations that have been adopted for that purpose by the Commission.

For those candidates who observe the Commission's timeline, it would be valuable for colleges and universities to advise them to earn either (1) a science credential with *two concentrations*, or (2) a science credential with a *supplementary authorization* in a second concentration area. Information about these options is on page 62.

Implementation Plan Adopted by the Commission

November 6, 1992

- (1) The Commission will review two kinds of proposals that respond to the Standards of Program Quality in Science. The Commission will grant *full approval* to programs that satisfy the full complement of standards in this handbook, based on the judgments of the program reviewers. The Commission will grant *interim approval* to programs that satisfy the full complement except for one or more of the standards concerning Program Coordination (Standard 13), Student Advisement (14) and Student Assessment (15).
- (2) An institution may seek full approval of some programs and interim approval of other programs. To seek full approval of a program, an institution must respond to all of the standards. To seek interim approval of a science program, the institution must respond to all of the standards except Standards 13, 14 and 15.
- (3) By January 1, 1995, existing ("old") programs based on current guidelines should be superseded by new programs with either full approval or interim approval.
 - (a) Once a new program receives full or interim approval, all students not previously enrolled in the old program (i.e., all "new" students) should enroll in the new program.
 - (b) After January 1, 1995, no "new" students should enroll in an "old" program, even if a new program in the subject is not available at that institution.
 - (c) Students who enrolled in an old program prior to January 1, 1995, may continue to pursue the old program [see (5) below].
- (4) By January 1, 1998, a program with interim approval must earn full approval. To seek full approval of a science program with interim approval, the institution should respond only to Standards 13, 14 and 15. If the program satisfies these standards, the Commission will grant full approval. An institution may seek full approval of a program with interim approval any time between the granting of interim approval and January 1, 1998.
- (5) Until January 1, 1998, students may qualify for examination waivers based on "old" program guidelines provided that the students entered the old program prior to either (a) the implementation of a new program with full approval or interim approval at their institution, or (b) January 1, 1995, whichever occurs first.

Timeline for Implementing the Science Standards

November 1991	The Commission on Teacher Credentialing adopts the Standards of Program Quality and Effectiveness that are on pages 15-33 of this handbook, and the preconditions on page 14.
November 1992	The Commission adopts the plan, on page 54, for implementing the standards and preconditions.
January to March, 1993	The Executive Director disseminates the handbook. The Commission conducts regional workshops to answer questions, provide information, and assist colleges and universities.
May to August, 1993	The Commission selects, orients and trains a Program Review Panel in Science. Qualified subject matter experts are prepared to review programs in relation to the standards beginning in 1993-94.
September 1993	Review and approval of programs under the new standards begins. No new subject matter programs in science will be reviewed in relation to the Commission's "old" guidelines.
1993-94 1994-95	Institutions may submit programs for preliminary or formal review on or after September 1, 1993. Once a "new" program is approved, all students who were not previously enrolled in the "old" program (i.e., all new students) should enroll in the new program. Students may complete an old program if they enrolled in it either (1) prior to the commencement of the new program at their campus, or (2) prior to January 1, 1995, whichever occurs first.
January 1, 1995	"Old" programs that are based on pre-1991 guidelines must be superseded by new programs with either full approval or interim approval (see pages 60-61). After January 1, 1995, no new students should enroll in an old program, even if a new program in science is not yet available at the institution.
1995-96 1996-97 1997-98	The Commission will continue to review program proposals based on the standards and preconditions in this handbook. Institutions with interim approval of a program may seek full approval of that program at any time before January 1, 1998.
January 1, 1998	A program with interim approval must earn full approval by the Commission. To seek full approval of a program with interim approval, the institution should respond to Standards 13, 14, and 15.
January 1, 1998	The final date for candidates to complete subject matter preparation programs approved under the pre-1991 guidelines. To qualify for a credential based on an "old" program, students must have entered that program prior to either (1) the implementation of a new program with full or interim approval at their institution, or (2) January 1, 1995, whichever occurs first.

Implementation Timeline Diagram

November 1991

Adopt the standards and preconditions in this handbook, for subsequent implementation.

November 1992

Adopt the revised timeline and implementation plan.

January to March, 1993

Disseminate the standards, timeline and implementation plan throughout the state. Conduct regional workshops to provide information, answer questions and assist institutions.

September 1993

Colleges and universities may begin to present program documents for review by the Commission's staff and Program Review Panels.

January 1, 1995

"Old" subject matter programs in science must be superceded by new programs with full approval or interim approval.

January 1, 1998

A program with interim approval must earn full approval by the Commission.

January 1, 1998

Final date for candidates to qualify for Single Subject Credentials in Science on the basis of "old" programs of subject matter preparation.

Implementation Handbook: Review and Approval of Subject Matter Programs in Science

A regionally accredited institution of postsecondary education that would like to offer (or continue to offer) a Program of Subject Matter Preparation for the Single Subject Credential in Science may present a program proposal that responds to the standards and preconditions in this handbook. The submission of programs for review and approval is voluntary for colleges and universities; candidates can qualify for the Single Subject Credential by passing a comprehensive assessment of their knowledge and competence in science.

For a subject matter program in science to be approved by the Commission, it must satisfy the preconditions and standards in this handbook. If an institution would like to offer two or more distinct programs of subject matter preparation in science, a separate proposal should be forwarded to the Commission for each program. For example, one program in science might emphasize the study of technology and society, while a second program at the same institution could have an emphasis in ethics of science.

The Commission is prepared to review subject matter program proposals beginning on September 1, 1993. Prior to that date, the Commission's professional staff is able to consult with institutional representatives, and to do preliminary reviews of draft proposals (see page 58 for details).

Initial Statement of Institutional Intent

To assist the Commission in planning and scheduling reviews of program proposals, each institution is asked to file a Statement of Intent at least four months prior to submitting a proposal. Having received a timely Statement of Intent, the Commission will make every effort to review a proposal expeditiously. In the absence of a timely statement, the review process will take longer.

The Statement of Intent should be signed by the individual with chief responsibility for academic programs at the institution. It should provide the following information:

- The subject for which approval is being requested (science).
- The contact person responsible for each program (include phone number).
- The expected date when students would initially "enroll" in each program.
- An indication as to whether or not the institution expects to submit a program for "informal" review (defined below).
- The date when each program will be submitted for formal review and approval.

If an institution plans to submit proposals for two or more programs in science, the Statement of Intent should include this essential information for each program, and should indicate whether or not the programs will have distinct emphases.

The Program Document or Proposal

For each program, the institution should prepare a program document that includes a narrative response to each precondition and standard on pages 14-33. Please provide six (6) copies of each program document.

Preconditions. A narrative section of the document should explain how the program will meet each precondition on page 14. In responding to the preconditions, the document must show the title and unit value of each required and elective course in the breadth component of the program (Precondition 2), and in each concentration (Precondition 3). The document must also include brief course descriptions.

Standards. In the major part of the program document, the institution should respond to each Standard of Program Quality and Effectiveness on pages 15-33. It is important to respond to each element of a standard, but a lengthy, detailed description is not necessary. An institution's program document should include syllabi of required and elective courses, to serve as "back-up" information for responses to particular standards.

Factors to Consider. A program proposal must show how the program will meet each standard. The purpose of factors to consider is to amplify specific aspects of standards, and to assist institutions in responding to all elements of a standard. The Commission considers the factors to be important aspects of program quality, but it is not essential that the document respond to every factor. The factors are *not* "mini-standards," and there is *no expectation* that a program must "meet" all the factors in order to fulfill a standard. (For added information about factors to consider, see pages 5 and 13.)

Institutions are urged to *reflect on* the factors to consider, which may or may not be used as the "organizers" or "headings" for an institution's response to a standard. The quality of a program may be enhanced by an "additional factor" that is related to a standard but not represented by any of the adopted factors. Institutions are encouraged to describe all aspects of the program's quality, and not limit their responses to the adopted factors in this handbook.

Steps in the Review of Programs

The Commission is committed to conducting a program review process that is objective, authoritative and comprehensive. The agency also seeks to be as helpful as possible to colleges and universities throughout the review process.

Preliminary Staff Review. Before submitting program documents for formal review and approval, institutions are encouraged to request preliminary reviews of *draft* documents by the Commission's professional staff. The purpose of these reviews is to assist institutions in developing programs that are consistent with the intent and scope of the standards, and that will be logical and clear to the external reviewers. Program documents may be submitted for preliminary staff review at any time; the optimum time is at least one month after submitting the Statement of Intent and at least two months prior to the expected date for submitting a completed document. Preliminary review is voluntary; its purpose is to assist institutions in preparing program documents that can be reviewed most expeditiously in the formal review process.

Science Program Quality Standards: Implementation Handbook

Review of Preconditions. An institution's response to the preconditions is reviewed by the Commission's professional staff because the preconditions are based on state laws and regulations, and do not involve issues of program quality. At the institution's discretion, preconditions may be reviewed either during the preliminary review stage, or after the institution's formal submission of a document. If the staff determines that the program complies with the requirements of state laws and administrative regulations, the program is eligible for a review of the standards by a panel of subject matter experts. If the program does not comply with the preconditions, the staff returns the document to the institution with specific information about the lack of compliance. Such a program may be resubmitted once the compliance issues have been resolved.

Review of Program Quality Standards. Unlike the preconditions, the standards address issues of program quality and effectiveness, so each institution's response to the standards is reviewed by a small Program Review Panel of subject matter experts. During the review process, there is an opportunity for institutional representatives to meet with the Program Review Panel to answer questions or clarify issues that may arise. Prior to such a discussion, the panel will be asked to provide a preliminary written statement of the questions, issues or concerns to be discussed with the college or university representative(s).

If the Program Review Panel determines that a proposed program fulfills the standards, the Commission's staff recommends the program for approval by the Commission during a public meeting no more than eight weeks after the panel's decision.

If the Program Review Panel determines that the program does not meet the standards, the document is returned to the institution with an explanation of the panel's findings. Specific reasons for the panel's decision are communicated to the institution. If the panel has substantive concerns about one or more aspects of program quality, representatives of the institution can obtain information and assistance from the Commission's staff. With the staff's prior authorization, the college or university may also obtain information and assistance from one or more designated members of the panel. After changes have been made in the program, the proposal may be re-submitted to the Commission's staff for re-consideration by the panel.

If the Program Review Panel determines that minor or technical changes should be made in a program, the responsibility for reviewing the re-submitted document rests with the Commission's professional staff, which presents the *revised* program to the Commission for approval without further review by the panel.

Appeal of an Adverse Decision. An institution that would like to appeal a decision of the staff (regarding preconditions) or the Program Review Panel (regarding standards) may do so by submitting the appeal to the Executive Director of the Commission. The institution should include the following information in the appeal:

- The original program document, and the stated reasons of the Commission's staff or the review panel for not recommending approval of the program.
- A specific response by the institution to the initial denial, along with a copy of the resubmitted document (if it has been resubmitted).
- A rationale for the appeal by the institution.

The Executive Director may deny the appeal, or appoint an independent review panel, or present the appeal directly to the Commission for consideration.

Responses to Six Common Standards

The Commission adopted six of the standards for programs in *all* single subject disciplines (i.e. science as well as other disciplines).

- Standard 1. Program Philosophy and Purpose.
- Standard 11. Equity and Diversity in the Program.
- Standard 13. Coordination of the Program.
- Standard 14. Student Advisement and Support.
- Standard 15. Assessment of Subject Matter Competence.
- Standard 16. Program Review and Development.

These six standards are referred to as “common standards” because they are essentially the same in all subject areas.

An institution’s program document in science should include a subject-specific response to Standards 1 and 11, along with subject-specific responses to the other curriculum standards in Category I (pp. 15-29). An institution’s program document in science *may* also include unique responses to Standards 13 through 16. Alternatively, the institution *may* submit a “generic response” to these four common standards. In a generic response, the institution should describe how credential preparation programs in all subjects will meet the four standards. A generic response should include sufficient information to enable an interdisciplinary panel of reviewers to determine that the four common standards are met in each subject area. Once the institution’s generic response is approved, it would not be necessary to respond to the four standards in the institution’s program document in science, or in any other subject. (Institutions seeking “interim approval” may submit a generic response to Standard 16 only. See below for information about interim approval.)

Full Approval and Interim Approval

Even after the Commission adopted the standards in this document, Commissioners were concerned that *some of the standards* might be prohibitively expensive for some institutions to implement during the current fiscal crisis. At the same time, the Commission did not want to delay implementation of all the standards by those institutions that can do so in the near term. To accommodate differences among institutions, the Commission adopted two options: address all of the standards or address all except 13, 14 and 15.

If the Program Review Panel determines that a program fulfills all of the standards, the panel will recommend *full approval* of the program by the Commission. If the panel finds that a program satisfies all of the standards except Standards 13, 14, and 15, it will recommend that the Commission grant *interim approval* to the program. The latter option will be available from 1993-94 through 1996-97.

To seek *full approval* of a program, the institution must address all standards. To seek *interim approval*, the initial program document must address all standards except 13-15. If the document addresses all standards, and the Review Panel finds that all standards are met except 13-15, the Commission’s staff consultant will contact the institution to determine if the Commission should grant interim approval to the program. The alternative in this case would be for the institution to re-submit the proposal for full approval after revising it in relation to Standards 13, 14, and/or 15.

Programs with interim approval must earn full approval before January 1, 1998. An institution that sponsors programs with interim approval may seek full approval at any time during 1993-94, 1994-95, 1995-96 or 1996-97. To seek full approval, the institution needs to respond only to standards that were not addressed in the initial program document. If the Review Panel determines that these standards are met, the panel will recommend that the Commission grant full approval to the program.

Selection, Composition and Training of Program Review Panels

Review panel members are selected because of their expertise in science, and their knowledge of science curriculum and instruction in the public schools of California. Reviewers are selected from institutions of higher education, school districts, county offices of education, organizations of subject matter experts, and statewide professional organizations. Members are selected according to the Commission's adopted policies that govern the selection of panels. Members of the Commission's former Single Subject Waiver Panels and Subject Matter Advisory Panels may serve on Program Review Panels.

The Program Review Panel in Science includes at least one professor of science, at least one high school teacher of science, and a third member who is either another professor, another teacher, or a curriculum specialist in science.

The Program Review Panel is trained by the Commission's staff. Training includes:

- The purpose and function of subject matter preparation programs.
- The Commission's legal responsibilities in program review and approval.
- The role of the review panel in making program determinations.
- The role of the Commission's professional staff in assisting the panel.
- A thorough analysis and discussion of each standard and rationale.
- Alternative ways in which the standard could be met.
- An overview of review panel procedures.
- Simulated practice in reviewing programs.
- How to write program review panel reports.

The initial phase of training involves panels that have been selected to review programs in several subject areas, and includes training in the Common Standards. In the concluding phase, the reviewers of science programs are trained specifically in the consistent application of the subject-specific standards in science.

Program Review Panel Procedures

The Program Review Panel meets periodically to review programs that have been submitted to the Commission during a given time period. Review meetings usually take place over three days, and typically adhere to the following general schedule:

- First Day - Review institutional responses to common standards. Preliminary discussion of responses to curriculum standards.
- Second Day - Thorough analysis of responses to curriculum standards. Prepare preliminary written findings for each program, and FAX these to institutions.

Science Program Quality Standards: Implementation Handbook

- Third Day - Meet with representatives of institutions to clarify program information, discuss preliminary findings and identify possible changes in programs. Prepare written reports that reflect the discussions with institutions.

Normally, the Program Review Panel's written report is mailed to the institution within two weeks after the panel meeting. If the report is affirmative, the Commission's staff presents the report to the Commission during a public meeting no more than eight weeks after the panel's decision.

If the report indicates that the program does not meet the standards, specific reasons for the panel's decision are included in the report. The institution should first discuss the report with the Commission's staff. One or more designated members of the panel may also be contacted, but only after such contacts are authorized by the staff.

If the report shows that minor or technical changes are needed in a program, the review panel gives responsibility for reviewing the re-submitted document to the staff.

Whenever possible, Program Review Panels in more than one subject meet at the same time and location. This enables institutional representatives to meet with reviewers in more than one subject area, if necessary. It also facilitates reviews of the common standards, and utilizes the Commission's staff resources most efficiently.

Supplementary Authorizations and Concentrations for Science Teachers

This handbook initiates a new structure for the Single Subject Teaching Credential, in which one science credential replaces two science credentials. In keeping with the new structure, each prospective teacher fulfills a standard of general knowledge and competence across the four science areas, and demonstrates specialized preparation by completing a concentration in one science area. The combined credential structure improves the preparation of all science teachers for assignments to broad classes in science, general science, life science, physical science and integrated science. For assigning teachers to advanced classes in chemistry, geology and physics, the new structure aligns each teacher's preparation with content-to-be-taught better than the prior credential structure.

It would be valuable for colleges and universities to advise prospective teachers of science to earn either (1) a science credential with *two concentrations*, or (2) a science credential with a *supplementary authorization* in a second concentration area. A student who completes the institution's requirements under any two of the concentrations under Standard 6 (A-D) can be recommended for a science credential with those two concentrations. Alternatively, a student can earn a supplementary authorization in biology, chemistry, earth science or physics while earning the basic teaching credential. Either of these options authorizes the teacher to teach specialized, advanced classes in two science fields, instead of one field. This versatility is beneficial to school districts as well as teachers seeking science positions. (For information about supplementary authorizations, please call the Commission's Information Services Office at 916-445-7254.)

Further Information and Communications Related to Standards, Programs and Program Reviews

Regional Workshops for Colleges and Universities

During March, 1993, the Commission will sponsor three regional workshops to provide assistance to institutions related to their subject matter programs in science. The agenda for each workshop will include:

- Explanation of the implementation plan adopted by the Commission.
- Description of the steps in program review and approval.
- Review of program standards, factors to consider, preconditions, and examples presented by Subject Matter Advisory Panel members and others with experience in implementing Standards of Program Quality.
- Opportunities to discuss subject-specific questions in small groups.

All institutions that plan to submit program documents (or are considering this option) are welcome to participate in the workshops. Specific information about the workshop dates and locations is provided separately from this handbook.

Communications with the Commission's Staff and Program Review Panel

The Commission would like the program review process to be as helpful as possible to colleges and universities. Because a large number of institutions prepare teachers in California, representatives of an institution should first consult with the Commission's professional staff regarding programs that are in preparation or under review. The staff responds to all inquiries expeditiously and knowledgeably. Representatives of colleges and universities should contact members of a Program Review Panel only when they are authorized to do so by the Commission's staff. This restriction must be observed to ensure that membership on a panel is manageable for the reviewers. If an institution finds that needed information is not sufficiently available, please inform the designated staff consultant. If the problem is not corrected in a timely way, please contact the Executive Director of the Commission.

Request for Assistance from Handbook Users

The Commission welcomes comments about this handbook, which should be addressed to:

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Professional Services Division
1812 Ninth Street
Sacramento, California 95814-7000